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The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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The Registered Office and Laboratories of the B.C.I.R.A. are:—
21-23, ST. PAUL'S SQUARE, BIRMINGHAM
Telephone: Central 1885. Telegrams: CIRA

The B.C.I.R.A. Scottish Laboratories are:—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone: 332

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The Home Office and the Factory

For some factories at least, the first contact with the Home Office on any one particular phase of activity is the receipt of an *Order*, couched in legal terms, requiring the responsible occupier to do this or that. Such an action, *force majeure*, is not one designed to put the average owner in the best of tempers. He naturally regards it as a matter involving an extra cost. Yet not every Order increases manufacturing costs, and, so far as home trade is concerned, the Order applies to all his competitors. Personal observation has convinced us that at least some Orders have resulted in distinct economies, and this is where we suggest that the factory-inspection section of the Home Office has "missed the boat." By co-operating with the management of certain factories they could produce balance-sheets to show that full and intelligent compliance with certain of their regulations is productive of increased profits.

In general, these Orders have for their object either the amelioration of working conditions from the angles of both increased safety for the operatives and cleanliness. In either case, lack of adequate provisions costs money. Accidents disorganise the factory, whilst dirt creates added expense in the maintenance of machines and adequate lighting. We well remember the inception of the Grinding of Castings Order, because we were strongly criticised by some foundry owners for lending this our support. Yet the results have justified the attitude we assumed. This Order has resulted in fettling being better laid out; work is more intelligently processed, the atmosphere is cleaner, and, moreover, it appears to us that, at least in the more-enlightened shops, costs have been reduced. If the factory inspectors had taken photographs, working details and costs before and after the conversations to comply with this Order, they would possess data which would help them to allay suspicion in connection with subsequent "impositions." The health and safety regulations are usually fairly reasonable, but some of these of an "ethical" character show a deplorable lack of knowledge of human psychology. Amongst these is the one envisaged for the compulsory appointment of safety-first officers for factories. For the largest factories of a certain type such an appointment is commendable, but for others it is better for the actual managers and foremen to assume responsibility for their own departments, with the works manager acting as the co-ordinating and directing official.

Eliminating the Accident-Prone

A good deal of publicity has been given to, and interest aroused by, a new angle of approach to the accident problem by the Medical Research Council in its recent annual report, an approach which is of interest to those engaged in industry as well as to those engaged in mechanical transport, for whom it is primarily intended. Incidentally, so many industrial products are distributed by road that the whole problem is of great importance to employers. The nation has been roused by the failure seriously to diminish the toll of the roads, and quite apart from the tragedy of the loss of life involved and the damage to property, the insurance premiums paid by all road users are inflated by the necessity for covering accidents which may be avoidable.

The report says that, with regard to industrial risks, it is well established that some persons are especially liable to be subject to accidents. For instance, if a body of people are subjected to the same risk, three-fourths of the accidents are confined to a small proportion of the total, say one-tenth. If all were equally liable to accidents, this result could not be obtained, and it holds good in most cases even if some of the accidents are just due to sheer bad luck or even to the actions of other people. To reduce accidents, therefore, we have to detect and eliminate this small proportion of accident-prone people.

It is suggested that, if a person is accident-prone, he will suffer accidents just as much in one period as in another, and those who suffer minor accidents tend to suffer major accidents, and *vice versa*. From four groups of over 2,000 drivers, records have shown that in each group some individuals are more liable to accidents than others. Those who suffer an undue number of one kind of accident tend to suffer an undue number of other kinds. Those who suffer an undue number in one period do so in other periods. The suggestion is that tests can be devised to pick out the accident-prone, and these can be eliminated. The examination of records can also be made to help, and this has nothing to do with who was to blame or whether legal proceedings were involved.

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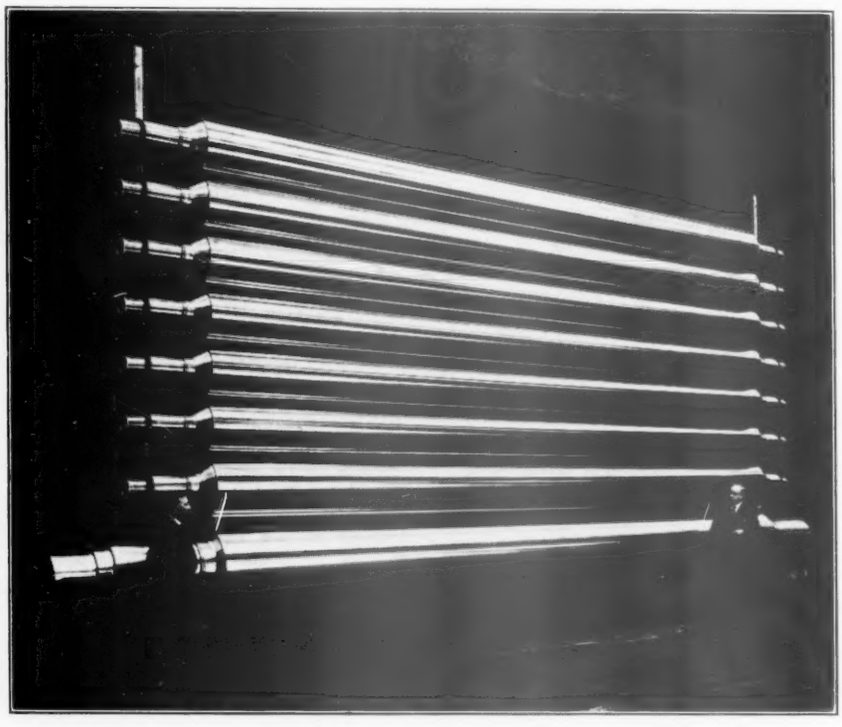
Paper-Machine Rolls

A large number of guests attended at the London Road Foundry in Edinburgh of Messrs. Miller & Company, Limited, engineers and iron-founders, on February 20, to inspect the largest stack of paper-machine calender rolls ever manufactured either in Britain or abroad. The firm, which was founded about 70 years ago, obtained the order in the face of keen German and American competition, and was the only firm in Great Britain in a position to quote for the work.

The machine in which the rolls will be operating when completed will be the largest and widest in existence, with a capacity of 1,000 tons of finished paper per week.

The total finished weight of the eight-roll stack is 133 tons 10 cwts., and it comprises one 36-in. dia. solid-bottom chilled cast-iron roll 310 in. wide, weighing 43 tons 10 cwts.; one 24-in. dia. second bottom chilled cast-iron roll 310 in. wide, weighing 18 tons; and six 20-in. dia. chilled cast-iron rolls 310 in. wide, weighing 12 tons each. With the exception of the bottom roll, all others are bored 3 in. for steam heating.



A GROUP OF CALENDER ROLLS MADE BY MILLER & COMPANY, LIMITED.

The firm was also entrusted with the manufacture of five chilled cast-iron rolls, of a total weight of 100 tons, for the super-calender which works in conjunction with the mammoth machine.

The work has occupied about twelve months, and the rolls have been made to the order of Messrs. Walmsleys (Bury), Limited, who are installing the machine for the Kemsley Paper Mills, Sittingbourne, Kent.

Among those who received the guests were Dr. Leonard T. Miller Gray, chairman of Miller & Company, Limited; Mr. Charles A. Rose, M.C., managing director; Mr. Thomas R. Scott, technical director; Mr. Matthew S. Calder, commercial director, and Mr. Richard T. Hartley, metallurgist.

MESSRS. S. P. AUSTIN & SON, LIMITED, Sunderland, have booked an order for a motor cargo vessel of 950 tons deadweight for Coast Lines, Limited, of Liverpool.

A New House Organ

The "Lysaght Review," which is to be published bi-monthly by Messrs. John Lysaght, Ltd., Newport, Mon., has now made its first appearance. It has set an exceedingly high standard for itself. The editor, Mr. Desmond Lysaght, has certainly a flair for journalism, both for the selection and presentation of material. The manufacture of sheet mill rolls is the subject of an article written by Mr. R. P. Perry, and makes a distinct contribution to the all-too-scanty literature of the subject. Other subjects covered are "The Future of Quality Sheet" and "The Romance of Steelmaking in Lincolnshire," the former being from the pen of Mr. G. C. Richer and the latter by Mr. W. J. Brooke. We felt ourselves a little flattered when we found a lengthy quotation from the leading article in our annual review number. Several pages are devoted to a digest of the month's technical news, and an extremely well-balanced selection has been chosen. We wish our new contemporary every success.

Demand for Steel

Speaking at a dinner at Middlesbrough organised by the Cleveland Institution of Engineers, the President, Lt.-Col. W. Routledge, said that the outstanding need of the moment was for further technical education. They were up against one of the most intensive periods in the history of the iron and steel trade, and the time was coming when they on Tees-side would have to go further in the direction of the production of the finished article. That could not be done without technical help and assistance. Mr. F. Kingsley Griffith, M.P., declared that unless the great industries of the country were carrying on by their own internal virtue and effort, Parliament could not make them succeed. All that Parliament could do was to create reasonable conditions under which industry could earn its success. Mr. F. E. Smith, chief engineer of Imperial Chemical Industries, Limited, at Billingham-on-Tees, said that the chemical industry was always asking for new steels, and in the last two years demands for steels which had never been made before in this country, and in many instances never made before in the world, had been met in a most amazing manner. Without that help hydrogenation would have been impossible.

The Spelter Situation

By "ONLOOKER."

Some weeks ago it was announced that the President of the Board of Trade had called on the Imports Duties Advisory Committee for a report on the spelter position in this country, and an immediate investigation was promised. So far no announcement has been made and the scarcity of supplies and onerous premiums above Metal Exchange prices, both matters of which the consumers have complained for months, continue to advertise the fact that all is not well and to suggest the advantage of arriving at a decision on these outstanding matters with all possible speed. In his letter to Sir George May, Mr. Runciman said the producers claimed that a solution to the present troubles would be reached were the London Metal Exchange price made "duty paid," *i.e.*, that the duty should be added to the official quotation, and instead of, as at present, being for buyer's account it would be an obligation on the seller.

This plan, if adopted, would mean that all Metal Exchange spelter, or, to be more precise, all spelter represented by warrants, would *already* have paid duty (if of foreign origin) and be available without further fuss or bother for consumers' use, and there is undoubtedly much to be said in favour of a scheme of this nature. Whether or no the present arrangement of bonded warehouse facilities would be retained is questionable, but there is really no reason why it should not continue, with the difference, of course, that spelter admitted there would not provide a backing for trading on 'Change, inasmuch as it would not have been sold and therefore have paid duty in accordance with the new scheme. At present foreign producers can sell on the L.M.E. and ship their product to this country for deposit in bond *without* paying the 10 per cent. *ad valorem* tax, so that a buyer in the spelter ring is more likely than not to find himself landed with a warrant backed by Continental metal on which duty must be paid before it can go into consumption. No wonder that manufacturers and others have fought shy of Whittington Avenue and continued, although unwillingly, to pay the premiums demanded for Empire brands.

While the plan outlined above might well lead to a considerable tonnage of foreign spelter becoming available for use at the consuming centres in the United Kingdom, it would, of course, establish firmly the right of the Empire sellers to trade on a taxed basis, for they would be pocketing the Metal Exchange price plus duty. Should the users admit the principle they would be turning their backs on the spirit underlying the Ottawa Agreement, and foregoing their right to purchase at the world price, for it is impossible to argue that a taxed quotation can be in the true sense of the word "real." Moreover, there must always be the fear that the added duty would become after a time so merged in the price as to be almost forgotten, and then unless very adequate guarantees had been given by the sellers the vicious circle might begin all over again with the addition of premiums.

To the unbiased observer one point stands out very clearly in this spelter trouble, and that is the fact that the Empire producers have failed in their responsibility to keep this country adequately supplied. If they cannot do this, and short of ceasing to supply other markets it does not seem as if they can, then the duty should be raised and free entry to foreign spelter restored.

Copper in Malleable Iron

A recent issue of "Metals Technology" contains a Paper by MESSRS. C. S. SMITH and E. W. PALMER on "Some Effects of Copper in Malleable Iron," in which it is pointed out that the presence of copper in malleable iron accelerates graphitisation.

Cupola Practice and Carbon Control*

By W. H. BAMFORD

In these days a Paper upon carbon control is by no means rare; in fact, judging by the number of articles published, too, on the effects of carbon in cast iron, it would seem that it is a fairly common subject, but at the same time, it also shows that it is of great interest to the majority of foundrymen.

There is nothing very startling in the control of the elements in the cupola when using straight pig and scrap mixtures, as the difference of these in the pig-iron and scrap is comparatively slight, and one can depend upon the usual 10 per cent. loss in silicon and the carbon tending to move towards its eutectic composition, unless something is radically wrong with one's practice.

When melting steel mixtures with a view to casting the product directly into castings, the difficulties are greatly increased, as the materials necessary, that is, the pig-iron and steel, are widely different in character, with a consequent difference in their reactions in the cupola; the melting points and specific gravity are widely dissimilar, which make much greater precautions necessary than with plain pig and scrap charges.

The greatly superior product obtained with steel, however, more than justifies its inclusion in the charge, while the greater precautions

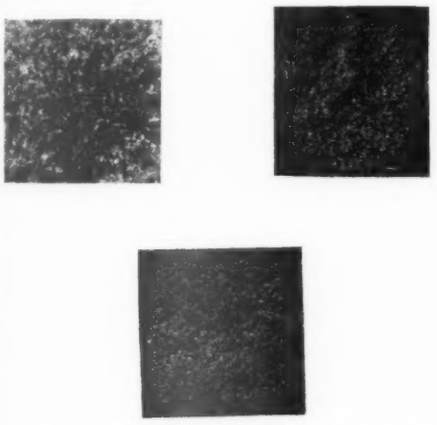


Fig. 1.—Fractures of Transverse Bars, having High (3.60), Medium (3.26), and Low (2.97 per cent.) Carbon, with Constant Silicon (2.10 per cent.).

needed are made worth while, if only for a saving in cost of material, steel scrap being much cheaper than pig.

Although semi-steel has been in general use for a considerable time, so far as can be ascertained, no particulars have been published relating to its continuous melting and direct casting over a period of 8½ to 9 hrs. a day, with the object of maintaining a constant chemical composition of the melt essential for repetition castings required for strength and freedom from all metal troubles.

It is the object here, therefore, to give a few details of experiences with this type of metal, as it has been found that, by suitably balancing the charges, it is possible to obtain an iron of almost any carbon content desired, keeping it to within as close limits as those obtained from electric furnaces, and far more cheaply. Along this path of precision in control of carbon lies the manufacture of alloy cast iron in the cupola also. To return to steel mixtures, while the saving in cost of materials has been considerable, there has also been a saving as a result of less scrap due to metal troubles, for which the introduction of steel has been largely responsible, mainly by lowering the total carbon.

With steel mixtures, difficulties arise in the control of the chemical composition, the total carbon offering the greatest, with the silicon becoming a poor second, but, with care and close supervision, it is possible to bring them both within very reasonable limits throughout a cast of 8 or 9 hrs., from the first ladle of iron tapped, until the last metal is drained from the well.

Details of the Melting Plant

Two cupolas are used for melting the cylinder iron, each with a shell of 54 in. lined to 40-in. dia. One is in use while the other is in course of preparation. They are of the soft-blast type, with a melting zone to tuyere ratio of 5 to 1. Blast is provided by a No. 3 Rootes blower, delivered at a pressure of 16-in. water gauge in the wind belt, and which may be by-passed to either cupola as needed. Metal is tapped into 6-cwt. ladles carried on overhead monorails to two mould conveyors, one bearing monobloc moulds and the other cylinder-head moulds.

It should be noted here that both monoblocs and heads are cast with similar iron, in green sand, no special distinction being shown to either; so that an iron conforming to both classes of castings is imperative. These conveyors are situated close to the melting section, so that little heat is lost during the transit of the metal to the moulds. This is important when dealing with a quick-setting iron, as any delay would give inconvenience from dull iron. An endeavour is made to cast all moulds as they proceed past the pouring station, or, in other words, synchronisation must be maintained between moulding and melting sections to give constant melting conditions in the cupola with the minimum of inconvenience from surplus or insufficient metal.

Cupola Preparation

Referring to the melting section, the cupolas are lit when preparation is finished, and the fire kept burning slowly throughout the night by night workers. If the ingress of air is strictly limited, combustion is slow and little coke is wasted. This serves the dual purpose of preventing spalling of the lining and aids in starting with a thoroughly incandescent bed, so necessary in order to obtain hot iron at the commencement of the blow. The blast is put on at approximately 8 a.m., and metal is usually ready for the first moulds to reach the pouring station about half an hour afterwards.

It is worthy of note that by having picked coke for the bed, and taking pains to obtain a highly-incandescent bed prior to charging, with the extra advantage of preheated ladles, it is possible to tap out at the commencement, metal sufficiently hot to cast cylinders and heads without having any of the inconvenience of dull iron. Indeed, this has become a general practice, due mainly to the willing co-operation of the staff attached to the cupolas, who, very humanly, dislike extra work in pigging cold iron.

The main feature of both the cupolas is in the wells. These are lined to hold their utmost capacity of iron, which is 30 cwts., when full to the slag hole. The wells, therefore, act as mixers in a modest way. Metal is tapped only when it is about to appear at the slag hole, which is kept permanently open during the day; this rule is never broken, unless unforeseen circumstances arise, and this partly makes it possible to control the silicon and phosphorus fairly closely.

Charging Details

A further and equally great precaution to ensure good mixing lies in the weight and positioning in the furnace, of the charges, which are composed of 4 per cent. silicon pig, own return scrap, and steel in suitable proportions to give a silicon content of between 2.1 and 2.3 per cent. and phosphorus not exceeding 0.25 per cent. The steel scrap added, which is of varied sections, never less than ¼ in., is in the proportion of 15 per cent. This percentage has been found to be the most economical for the production of the carbon content most suitable for cylinder castings, and it is safe to say that it has not been altered to any appreciable extent for eighteen months. The charges are weighed in thousand pounds on dial-reading scales, but the materials are halved when placed in the cupola. This

Fig. 2.—Valve Guide Holes having High (3.57) and Normal (3.60) Carbon, with Silicon at 2.10 per cent.

makes the charge only 500 lbs., which is small in comparison with a normal one for a furnace of this capacity, but the object will be appreciated when it is realised that there are always between five and six charges in the well.

Cupola practice in the past has recommended that the charges should be proportioned according to the weight of coke occupying a known depth in the shaft. While this may be usual, no difficulty has arisen as a result of reducing the weight of the charge, and similarly the coke, which is insufficient entirely to separate one charge from another.

The steel scrap is scattered over the coke, the pig placed around the edge, and the lighter scrap distributed evenly over the whole. Melting is thus very regular, and at the same time the metal is quite hot, probably in the region of 1,400 deg. C. This is most important when dealing with a quick-setting iron possessing a high freezing range.

From a description of the cupola practice and the precautions taken to keep the silicon and phosphorus within limits, it is thought advisable to proceed next to the most important element present in cast iron, which is carbon. It has been found that for strong castings of fairly close grain, with easy machining qualities, the most satisfactory carbon content lies between 3.1 and 3.3 per cent. Before going into details,

Fig. 3.—Cylinder Bores, Longitudinal Section, with Normal and Coarse Grain (C 3.58 and 3.26).

however, concerning the control of this element, it is probably as well to discuss the troubles which arise when it gets out of control, for it is more from mistakes and their rectification that information is gained, than from anything else.

Melting Troubles

Broadly speaking, metal troubles experienced with monoblocs and heads can be assigned to two main causes, which are:—(1) Open metal and porosity; and (2) hard or chilled iron. They are

* A Paper read before the Birmingham and West Midlands Branch of the Institute of British Foundrymen, Mr. G. T. Lunt presiding.

directly opposed to each other, and are the result of exactly opposite conditions. For example, if one of these is experienced in a casting, the other will certainly not be there; this remark applies solely to the type of iron and castings under discussion; no attempt is made at generalising. To counteract the first, that is, open metal, numerous suggestions have been advocated, but all with the same intention of producing castings of a quick-setting iron. One of these recently was to decrease the phosphorus to as low a limit as convenient in order to prevent segregation of phosphide eutectic, which, freezing in the region of 800 deg. C., naturally extended the setting time of the iron considerably, although against this it must be argued that perfectly good cylinders have been made with high phosphorus iron, so it is assumed that phosphorus in itself is not a direct cause of porosity.

If design of the casting does not enter into the problem of open metal, then the chief causes are as follow, in order of importance:—(1) High carbon; (2) high silicon; and (3) high casting temperature. Each of these factors is known to be capable of exerting an influence over the growth, and, therefore, the ultimate size of the graphite crystals, although probably in different ways.

High silicon opposes retention of carbon in solution; it is reasonable, too, to expect more graphite to be present in a high-carbon iron than in a low one; high casting temperature would certainly aid graphitisation by prolonging the time of cooling during the critical stages. While these are all contributory causes of open metal and porosity, it will be seen that they are directly associated with the precipitation of carbon.

Hard or chilled castings, on the other hand, are the result of opposite conditions, as stated previously, which are:—(1) Low carbon; (2) low silicon; and (3) low casting temperature. Here, again, it is the carbon that is the predominating factor, upon whose inadequacy the cause of the defect must lie, because necessary precautions have been taken to prevent bad mixing, while low casting temperature is due to the human element. Ruling out, therefore, the possibility of these two as unlikely causes of hard castings, it is evident that excessively low carbon is also a thing to be avoided as completely as is high carbon.

The pursuit of a quick-setting iron which does not readily chill lies, therefore, in a correct balance of the carbon to suit the casting, remembering that it is the most fluidising element present in iron. This will be more greatly appreciated after a study of the iron-carbon diagram, which shows that even slight differences in the amount of carbon present will alter considerably the temperature at which the iron commences to freeze.

TABLE I.—*Control of Cylinder Iron Composition.*

No.	C.C.	T.C.	Mn.	S.	P.	Si.	Br.	Chill in in.	Shrink in in. per ft.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.			
1	0.60	3.55	0.96	0.105	0.30	2.24	228		0.168
2	0.53	—	—	—	—	2.27	241		0.147
3	0.47	3.22	0.86	0.107	0.31	2.18	241		0.178
4	0.51	—	—	—	—	2.22	228		0.155
Lunch hr.									
5	0.52	—	—	—	—	2.18	228		0.160
6	0.50	3.36	0.84	—	0.29	2.04	241		—
7	0.53	—	—	—	—	2.09	241		0.160
8	0.53	3.36	0.80	0.096	0.30	2.10	241		0.159

High bed at commencement of melting results in high carbon, producing low chill.

TABLE II.—*Control of the Properties of Cylinder Iron.*

No.	C.C.	T.C.	Mn.	S.	P.	Si.	Br.	Chill in in.	Shrink in in. per ft.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.			
1	0.64	3.05	0.79	0.096	0.23	2.09	241		0.205
2	0.60	—	—	—	—	2.05	241		0.160
3	0.54	3.46	—	—	—	2.04	228		0.159
4	0.60	—	—	—	—	2.02	241		0.165
5	0.53	3.22	—	—	—	2.00	241		0.199
6	0.54	—	—	—	—	2.06	241		0.185
Lunch hr.									
7	0.57	3.19	0.94	0.095	0.21	2.07	255		0.197
8	0.56	—	—	—	—	2.04	248		0.169
9	0.53	—	—	—	—	2.03	241		0.157
10	0.56	—	—	—	—	2.15	241		0.162
11	0.51	3.30	1.04	0.093	0.21	2.26	228		0.159

Low bed at commencement produces low carbon with increased chill and shrinkage. The low carbon in the middle of the day, Nos. 5 to 7 also produced high chill and shrinkage.

Influence of Carbon

The influence of carbon is shown by Figs. 1 to 5, which illustrate defective castings, the chemical compositions of which are normal, except for this one element. Figs. 4 and 5 show castings possessing extremely high-carbon contents, which defect has been augmented by high casting temperature. They should not only open grain structures, but also liquid shrinkage, cavities or "draws." These cavities are caused by excessively fluid iron setting over a longer period than usual, which would be the case with a high-carbon iron, on account of its lower freezing temperature. If examined closely, they reveal themselves as composed of a network of dendrites of low-carbon iron, from which has receded the iron richer in carbon to feed other sections. This, again, is proved by the iron-carbon diagram in the liquidus and solidus curves, which show that iron, low in carbon, is the first to freeze, and, as crystallisation proceeds, the remaining liquid becomes richer in carbon, until freezing is complete.

When the carbon is known to be too high, the obvious precaution *id est* to reduce the ill-effects resulting is to depress the casting temperature, in order to shorten the setting time and aid chilling, but even here, increased precipitation and growth of graphite is inevitable, giving a more or less coarse grain structure.

Even when working with a low-carbon iron, this precaution is sometimes necessary with certain types of castings; for example, the smaller monoblocs the casting temperature of which is always strictly limited to produce a fine grain, owing to its small size and proportionately thicker sections being more conducive to open metal. All the illustrations demonstrate that control of the carbon is essential for success in minimising scrap, especially to a foundry engaged in repetition work, where no stone should be left unturned in maintaining consistency of product.

TABLE III.—*Control of the Properties of Cylinder Iron.*

No.	C.C.	T.C.	Mn.	S.	P.	Si.	Br.	Chill in in.	Shrink in in. per ft.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.			
1	0.58	3.33	0.98	0.105	0.22	2.07	228		0.170
2	0.52	3.55	—	—	—	2.05	228		0.160
3	0.50	3.60	—	—	—	2.02	241		0.160
4	0.51	—	—	—	—	2.16	269		0.160
5	0.54	—	—	—	—	2.03	241		0.164
Lunch hr.									
6	0.56	—	1.00	0.110	0.22	2.09	228		0.163
7	0.50	3.38	—	—	—	2.23	241		0.156
8	0.52	—	—	—	—	2.18	228		0.160
9	0.50	3.46	—	—	—	2.14	228		0.160
10	0.54	3.30	0.96	0.107	0.19	2.07	228		0.142

Fusion charges too heavy. Note gradual increase of carbon and reduction in chill. This was remedied and remaining figures are normal.

TABLE IV.—*Control of the Properties of Cylinder Iron.*

No.	C.C.	T.C.	Mn.	S.	P.	Si.	Br.	Chill in in.	Shrink in in. per ft.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.			
1	0.56	3.44	0.84	0.099	0.30	2.24	241		0.169
2	0.53	—	—	—	—	2.27	241		0.160
3	0.52	—	—	—	—	2.30	241		0.163
4	0.52	—	—	—	—	2.26	241		0.161
5	0.50	3.11	—	—	—	2.28	241		0.188
Lunch hr.									
6	0.52	3.41	0.86	0.115	0.32	2.21	228		0.163
7	0.50	—	—	—	—	2.30	241		0.157
8	0.52	—	—	—	—	2.32	235		0.164
9	0.50	3.14	—	—	—	2.28	241		0.188
10	0.52	—	0.86	0.115	—	2.22	241		0.159

Fusion charges too light. This was balanced after the lunch hour by the extra coke added for this purpose, but the height of the bed gradually dropped.

Factors Influencing Carbon Control

It is possible to keep the silicon and phosphorus constant, as previously stated, by reducing the size of the charge, increasing the capa-

city of the well, and taking care to tap out only when the well is full, but, unfortunately, the total carbon is not controlled so easily. The carbon content of the melt is dependent entirely upon other factors, of which the main ones are:—(1) Height of the coke bed; (2) size of the coke in the bed; and (3) quality of the coke used. As most of the fans or blowers used on cupolas are installed to suit individual furnaces, the quantity of air delivered need not be considered here, except when the furnace is being blown down, when, of course, it is necessary slowly to reduce the blast to coincide with the gradual lowering of the resistance in the shaft. With some fans, even this becomes unnecessary, as they are designed to give a constant air weight irrespective of any variation of resistance in the cupola.

The quantity and quality of the coke used are the all-important factors which govern the absorption of carbon in melting, which in turn has a direct influence upon the hardness, fluidity, and consequently the soundness of the iron at any particular time of melting. The reason is that the greatest amount of pick-up occurs in the melting zone, which is the hottest part of the cupola; the pick-up elsewhere is negligible. This was proved by examination of samples taken from the cupola as follows:—(1) Samples of partly-melted steel recovered from the drop revealed only slight skin penetration, and (2) prolonged proximity of metal and coke in the well has no influence on the carbon absorption whatever. This has been confirmed on numerous occasions by Mr. W. B. Parkes, chemist at the Austin Motor Car Company, during the last three years, who has tested samples of iron which have remained in the well for nearly 2 hrs. The carbon contents were no higher than the usual figures.

The pick-up of carbon in the melting zone and not in the other part of the shaft or well is explained by the greater affinity of iron for carbon at elevated temperatures, such as those occurring in the melting zone, where the iron probably reaches a temperature in the region of 1,500 deg. C.

TABLE V.—*Control of the Properties of Cylinder Iron.*

No.	C.C.	T.C.	Mn.	S.	P.	Si.	Br.	Chill in in.	Shrink in in. per ft.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.			
1	0.52	3.30	0.96	0.097	0.26	2.10	228	1/16	0.160
2	0.52	—	—	—	—	2.22	228	5/32	0.163
3	0.48	—	—	—	—	2.18	235	5/32	0.157
4	0.46	—	—	—	—	2.12	228	3/32	0.159
5	0.50	3.14	1.06	0.097	—	2.24	241	1/16	0.184
Lunch hr.									
6	0.53	3.16	—	—	—	2.16	241	1/16	0.189
7	0.46	—	—	—	—	2.28	241	5/32	0.163
8	0.51	—	—	—	—	2.28	255	1/16	0.160
9	0.50	—	—	—	—	2.23	255	1/32	0.159
10	0.49	3.33	1.22	0.101	0.28	2.25	228	1/32	0.167

Low carbon at the lunch hour, probably due to collapse of ganister patching and insufficiently balanced by the extra coke.

TABLE VI.—*Control of the Properties of Cylinder Iron.*

No.	C.C.	T.C.	Mn.	S.	P.	Si.	Br.	Chill in in.	Shrink in in. per ft.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.			
1	0.47	3.46	0.78	0.105	0.28	2.28	228	1/16	0.155
2	0.52	—	—	—	—	2.30	228	1/16	0.162
3	0.51	—	—	—	—	2.26	228	1/32	0.163
4	0.50	—	—	—	—	2.28	228	—	—
Lunch hr.									
5	0.51	3.44	0.86	0.124	0.30	2.18	228	1/16	0.160
6	0.44	—	—	—	—	2.28	228	1/16	0.160
7	0.46	—	—	—	—	2.28	228	1/32	0.158
8	0.51	3.14	0.88	0.116	0.30	2.20	255	1/32	0.197

Low carbon at end of day due to not regulating the blast to coincide with the lowering of resistance in shaft.

Carbon Pick-up in Well

Disregarding the pick-up in the well and the upper part of the shaft as negligible, places the bed in greater prominence as that portion of the furnace which controls the resulting carbon content of the iron, that is, if the bed be high; the reverse naturally obtains if the bed is low. Thus the rate of absorption increases or decreases according to the quantity of incandescent coke exposed to the liquid iron running through the bed. A similar condition arises when an excessive quantity of small coke is charged, which when it reaches the bed affords ideal condition for increased pick-up. These facts prove that the control of the carbon lies fundamentally in the control of the bed, that is, in maintaining a height most suitable for the required carbon content, having regard also to keeping a good average size of coke in each charge neither excessively large nor yet too small. By keeping the height of the bed constant the carbon pick-up will also keep constant for as long a period as melting continues.

Assuming that a highly superheated iron is required for thin castings, it seems inevitable that in raising the bed necessary for the additional heat required, the carbon in the melt is increased out of all proportion to the limits stipulated for a close-grained casting free from porosity. How is it possible, therefore, it may be asked, to obtain a low-carbon iron with a high degree of superheat also? The answer lies, firstly, in the selection of the steel scrap and the quantity it is possible to include in the charge without seriously lowering the silicon content, and secondly, in the quality or grade of coke used.

TABLE VII.—*Control of the Properties of Cylinder Iron.*

No.	C.C.	T.C.	Mn.	S.	P.	Si.	Br.	Chill in in.	Shrink in in. per ft.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.			
1	0.56	3.41	0.92	0.097	0.29	2.02	241	1/16	0.160
2	0.53	3.57	—	—	—	2.12	207	1/16	0.158
3	0.53	3.55	—	—	—	2.12	228	3/32	0.168
4	0.52	—	—	—	—	2.16	228	1/16	0.160
5	0.53	—	—	—	—	2.22	217	1/32	0.152
6	0.50	—	1.04	0.110	0.28	2.18	217	1/32	0.159
Lunch hr.									
7	0.55	—	—	—	—	2.02	228	1/16	0.160
8	0.49	3.61	—	—	—	2.17	207	1/32	0.160
9	0.50	—	—	—	—	2.08	228	1/32	0.158
10	0.56	—	—	—	—	2.06	241	1/32	0.155
11	0.50	3.43	1.02	0.099	0.28	2.06	228	1/32	0.155

High carbon persisting through day due to incorrect weight of fusion charge combined with large amount of small coke. This gave trouble due to open metal and porosity.

TABLE VIII.—*Control of the Properties of Cylinder Iron.*

No.	C.C.	T.C.	Mn.	S.	P.	Si.	Br.	Chill in in.	Shrink in in. per ft.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.			
1	0.59	3.11	1.26	0.090	0.22	2.30	—	1/16	0.166
2	0.53	3.11	—	—	—	2.32	—	1/16	0.160
3	0.55	—	—	—	—	2.24	—	1/16	0.163
4	0.56	—	—	—	—	2.26	—	1/32	0.158
5	0.50	3.22	—	—	—	2.28	—	1/16	0.164
Lunch hr.									
6	0.51	—	1.20	0.118	0.22	2.21	—	1/16	0.163
7	0.55	—	—	—	—	2.32	—	1/32	0.165
8	0.53	—	—	—	—	2.32	—	1/16	0.166
9	0.52	—	—	—	—	2.30	—	1/32	0.154
10	0.50	3.16	1.16	0.123	0.22	2.28	—	1/32	0.162

Normal day's results of a more recent day's cast. Note the lower carbon balanced by increased silicon.

Steel Scrap Selection

In reviewing the first part, that of selection and quantity of steel used, it has been found that thick-sectioned steel permits of less carbon absorption than does thin-sectioned steel, and where possible it could be used; but in circumstances where it is necessary to utilise the materials at hand, for example, mixed scrap, it is advisable to seek other means of keeping the carbon low. Again, an increase of steel to this end is not often economical, as it entails an increase of pig also to preserve the required silicon, thus reducing the percentage of return scrap in the charge accordingly.

Influence of Coke Reactivity

Ruling out any alteration in the percentage of steel used as impracticable, it is the quality of coke which must be reviewed in order to obtain one which, when extra is added to the charge for additional superheat, does not give appreciable carbon increase. In other words, the degree of absorption depends partly upon one other factor, which is the reactivity of the coke employed. The reactivity varies according to its density, the heavy dense types having a low reactivity, while the lighter, more open grades, such as gas coke, to quote an extreme, have a high reactivity.

The heavier types carburise less readily than do the lighter grades, and by the use of the

former it is possible to keep the carbon pick-up to low figures, even when using increased coke to obtain very hot iron, such as is necessary for cylinders.

As an example, given similar irons and identical melting conditions, but using two different qualities of coke, it is possible that the carbon in the melts could vary as much as 0.4 per cent. one with the other. This is the most important feature of the whole, as upon the wise choice of a suitable grade of coke, balanced with the metal charged, a definite

Fig. 4.—Cylinder Bores, showing Open Grain and Shrinkage (C, 3.61; Si, 2.15).

amount of carbon can be obtained in the melt for as long a period as desired.

Fig. 6 shows a comparison between two types of cupola coke; one is dense and heavy and admirably suited for the production of high temperature, low-carbon iron, the other is a less dense but equally good-quality coke, which when attempts have been made at increasing the height of the bed in order to obtain hotter iron, has resulted in an iron much higher in carbon than required.

Prior to using the dense coke, efforts were made to reduce the higher reactivity of the more open-grained coke, especially at the commencement of the day. At the start it is always necessary to have the bed much higher than the normal working height, for obvious reasons, so that unless precautions are taken to counteract the influence of the high bed the carbon pick-up would be great. It was the general practice, therefore, to build up the bed to the required height with large coke, which had been dipped in lime wash, the covering of lime lowering the reactivity appreciably. The first few charges of metal and coke were also limed. At the end of the sixth 1,000-lb. charge, half-a-fusion charge of the coke was left out. This satisfactorily lowered the bed to the normal working level and seldom were the bars, cast at the start, beyond the working limits. With low-reactivity coke these precautions are found to be unnecessary; the bed has to be almost extremely high before the pick-up is appreciable.

While the great danger with the lighter cupola coke lay chiefly in the production of a high-carbon iron, which was sometimes in the region of 3.5 to 3.6 per cent., the danger with the dense coke lies more in the production of very low-carbon iron, which means that it is advisable to have the working bed higher when using dense coke to prevent any possibility of hard castings, due to low-carbon cause, by the bed becoming low. The fact that the different grades of coke available vary in reactivity, suggests that it is easily possible to obtain one, after a little experiment, to satisfy one's individual needs.

Cupola Bed Control

Returning to the control of the bed and similarly the carbon; prior to charging, the height must be carefully measured, and if necessary made up to the required level. With the cupolas in question, 24 in. above the tuyeres was found to be the maximum height permissible when using the lighter grade of coke, which in conjunction with the coating of lime gave a constant carbon content day after day in the first metal melted. Above this height the carbon rose in proportion.

Using dense coke, it is possible to exceed this height by 4 or 5 in. without producing excessively high carbon. This is a great advantage, as it permits of hotter iron at the start. The most suitable height at the commencement and the weight for each charge can only be determined by experiment to suit individual foundries, and figures quoted here can only serve as a guide, but suffice it to say that the fusion charge must be accurately weighed for each charge.

It is important, too, that the charges of metal should not be large, as it would mean also correspondingly large charges of coke, which, as they reached the bed, would cause violent fluctuations in the height of the bed. To quote an example, if metal charges of 15 cwts. to 1 ton were the practice, as is common with this diameter of furnace, then, using a metal-to-coke ratio of 10 to 1 would necessitate a coke charge of nearly 2 cwts., which would occupy a height in the shaft of approximately 12 in. Thus, when each charge came into position for melting, the height of the bed would vary accordingly, and would create unfavourable conditions, especially if a low-carbon iron were desired as the best position for the steel when charging is adjacent to the coke. Under this category also comes the common, but bad, practice of adding extra coke to separate one mixture from another, as this will result in a temporary high bed, detrimental to uniformity. In this case, it would be preferable to drain the cupola and recharge.

Control by Keep's Tests

The test found to be the most suitable for a rapid and accurate determination of the amount of carbon present is found to be Keep's test. It is very simple, and consists of two bars, one 1 in. sq. transverse bar, which is broken on 12-in. centres, the other a $\frac{3}{8}$ in. sq. bar cast between the arms of a chill exactly a foot apart, which is inserted in the mould. On this smaller bar is measured the depth of chill and the lineal shrinkage. The fractures of both bars are also examined.

Any variation of the carbon is immediately reflected in the chill bar, which makes it quite a delicate test. Results can also be obtained rapidly, which is a great advantage, since, should the tests be beyond the limits, adjustments can be made almost immediately. The limits found to be most suitable for crank-case cylinders and heads, cast in green-sand moulds,

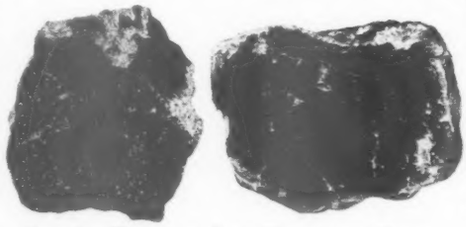


Fig. 6.—High and Low Reactivity Cokes. Both Good Quality.

are as follow:—Depth of chill, $\frac{7}{16}$ to $\frac{3}{4}$ in.; lineal shrinkage, 0.150 to 0.170 in. These correspond with a silicon of 2.1 to 2.3 per cent. in conjunction with a total carbon of 3.10 to 3.30 per cent. If the carbon rises much above 3.30 per cent., the increase is shown in the depth of chill, which falls proportionately to the increase of carbon; the shrinkage, however, appears to be unaffected. On the other hand, if the carbon falls much below 3.1 per cent., then the depth of chill increases, and with it the lineal shrinkage also.

A set of test-bars are cast every hour, and more often if unforeseen circumstances arise, or if it is necessary to make an alteration in the mixture. This includes bars cast from the first and last ladleful of iron tapped in the morning and afternoon. The results of each set, that is, the depth of chill, shrinkage and classification of fracture of the small bar, is noted soon after it is cast on a board located not far from the melting section, so that the staff engaged on this section can keep an interest in their work.

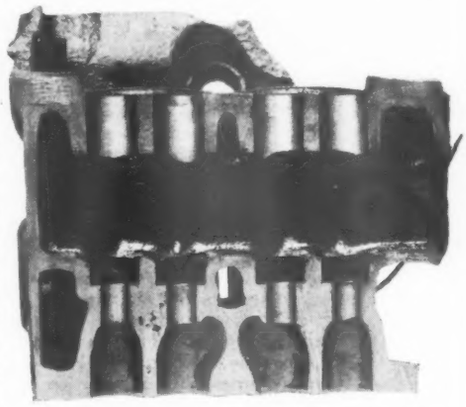


Fig. 5.—Monobloc shown through Valve Guide Holes, showing Liquid Shrinkage Cavities (T.C., 3.56; Si, 2.2 per cent.).

Excessive Carbon Pick-up

A greater increase in carbon pick-up than that which is expected may generally be ascribed to three causes: (1) Bed too high, either as a result of incorrect measurement at the start or incorrect weight of the coke splits, (2) too much small coke in the bed and (3) insufficient limestone. Extremely low carbon is brought about by reasons other than insufficient weight of coke split, such as: (1) Collapse of the patching, which when fluxed away causes a settling down of the coke to fill the space formerly occupied by the ganister and (2) shutting off the blast for any length of time, such as during the lunch hour, also results in a low bed, owing to the gradual settling of the partly-suspended coke and slag caused by the relief of pressure.

Whilst collapse of the patching can be guarded against with care, shutting off the blast constitutes a definite complication unless suitable precautions are taken beforehand. With a continuous casting plant, when moulds are cast almost as soon as they are made, it is impossible to keep a reserve of moulds for the lunch hour, during which period mould production has entirely ceased. It will be seen, too, that shutting off the blast for any length of time will at the re-start give rise to inconvenience with an unavoidable quantity of dull metal, which is, to say the least, uneconomical.

These two evils, that of low carbon and dull iron, can be overcome satisfactorily by adding extra coke—about half a charge has been found to be most convenient—prior to shutting down, so that its presence is felt in the bed just when the blast is shut off. With practice this can be timed fairly accurately. A precaution also advisable is to empty the well completely at the time of shutting down. The blast has been shut off satisfactorily this way, for as long as 1½ hrs., without the iron becoming too cold.

Tables I to VIII demonstrate the effects on the physical properties when the carbon exceeds the normal limits. Each table is representative of a full working day of about 8 hrs.' continuous melting, with tests taken at regular intervals. The first seven analyses were taken from records when this method of melting control was originally adopted, about two years ago.

The last one is of more recent date when the carbon was reduced to lower limits and the silicon raised to maintain easy machining qualities.

(*Concluded on page* 174.)

Deoxidation and Degasification of Non-ferrous Casting Alloys

AN INTRODUCTION TO THE SYMPOSIUM ON NON-FERROUS CASTINGS*

By C. H. LORIG,† Columbus, Ohio, U.S.A.

GENERAL PRINCIPLES

In this second annual symposium on deoxidation and degasification of non-ferrous casting alloys, the influences in metals and alloys of elements that exist as gases in their normal free state will be repeatedly brought to the foreground. Such elements are in almost every industrial metal and alloy, but, unfortunately, it appears, less is known about their effect and distribution than is known about the more obvious metallic forms of impurities. As the problems relating to deoxidation and degasification are both complex and confusing, a review of some general principles underlying the existence and control of non-metallic elements in metals seems warranted.

Before proceeding with the subject, a word may be said on nomenclature. In adopting the term "non-metallic elements" as descriptive of the substances usually involved in the word "gases," the proposal of a committee recently appointed by the Iron Steel Division of the A.I.M.E.‡ to study the nomenclature relative to the general subject of gases in metals is given recognition. The term non-metallic elements is less confining and more explicit than the word gases, and it removes some of the needless confusion introduced by the latter. It is, of course, as applicable to non-ferrous as it is to ferrous metals and alloys, including as it does such elements in oxygen, nitrogen, hydrogen, carbon and sulphur.

The sources for non-metallic elements in metals are numerous. They may enter the metals with the raw materials, fuel and fluxes, or they may come from the products of combustion, from the furnace atmosphere, from reactions between the metals and the furnace gases, from moisture in the crucible and refractories, from entrapped gases in the mould, from reactions between the metals and the mould materials, and from gas generated in the mould or core. For the most part, however, the presence of dissolved non-metallic elements in the melt may be ascribed to two major sources: first, from direct contamination of the melt by furnace fuels and products of combustion, and second from the metals used to make up the alloys.

Moisture Causes Difficulties

In each of the foregoing it is moisture to which most of the difficulties ascribed to non-metallic elements can be traced. It reacts with a large number of molten metals to form an oxide that is either dissolved, suspended, or slagged off, and hydrogen, part or all of which may be absorbed by the metals. Some hydrogen may be absorbed by metals through contact with ammonia and hydrocarbons, yet the chief source for hydrogen pick-up is from the reaction of the metals with moisture. Since hydrogen is recognised as one of the principal elements in promoting unsoundness in some castings, its importance must not be overlooked.

The introduction of oxygen from moisture into metals has been referred to. Other sources for oxygen are corroded or moist metal in the melting charge, oxygen in the atmosphere, and carbon monoxide and dioxide, the latter either dissolving in the metal or reacting to form metallic oxides.

While other non-metallic elements sometimes give rise to unsoundness in castings, the major causes for this condition are likely to be traced to the elements hydrogen and oxygen. In consequence of this, their rôles are particularly emphasised in this discussion on principles.

Certain non-metallic elements are simply dissolved both in the liquid and in the solid metals, and others are in suspension either as gases or vapours in blowholes and shrinkage spaces, or as liquid or solid inclusions. Whether in solution or existing as liquid or solid inclusions, hydrogen, oxygen, and other elements lose their identity as gaseous elements and form structures with metals that are analogous to those formed by some elements solid under ordinary atmospheric conditions. Thus, hydrogen may occur in metals as atomic hydrogen and as hydrides in solution or in suspension; likewise oxygen may occur as atomic oxygen or oxides, and nitrogen as atomic nitrogen or nitrides. Their solubility expressed in weight percentages in liquid and solid metals is small, with the solubility in the liquid generally the greater.

Hydrogen will dissolve with ease in many molten metals. The reason, perhaps, is because it is a small atom and hence possesses more penetrative and diffusive ability than most other non-metallic elements. Because of this and of its abrupt discontinuity in solubility at solidification temperatures, hydrogen has been recognised as one of the principal elements in promoting unsoundness in castings. There are cases where hydrogen appears to form true alloy systems with metals, as with palladium, cobalt, and nickel.

Whereas hydrogen, for the most part, simply dissolves in the metals, oxygen combines with most of them to form oxides. Though the oxides most frequently occur as slag inclusions of various kinds, some of the oxides are slightly soluble in liquid metals and later precipitate in the grain boundaries of the solidifying metals where they profoundly influence the properties of the metals.

There are several instances, however, as for example, with the metals silver, platinum and palladium, where oxygen seems to dissolve as the element. On its release during solidification it gives rise to the sudden spitting or sprouting that often occurs on the freezing surfaces of these metals, particularly silver. It is from a knowledge of the kinds of non-metallic elements in the metals, their mode of existence, and the manner in which they may be eliminated or rendered harmless that principles governing deoxidation and degasification of metals are established.

Principles Governing Solubility of Non-Metallic Elements in Metals

The distribution of non-metallic elements in solid and in liquid metals differs in degree, but not in kind. In solid metal the solubility of non-metallic elements increases linearly up to the melting point; in liquid metal their solubilities are usually greater and increase rapidly with the temperature. When in solution, their concentration is not directly proportional to their partial pressure in the surroundings, but is proportional to the square root of the partial pressures. This indicates that these elements in solution must either dissociate into the atomic state upon absorption by the metal, or they are in solution as some simple compound with the metal. The ability of a metal to dissolve these elements should then depend on the ability of that metal to dissociate them or to form soluble compound with them. It must be admitted, however, that the relation between the absorbed elements and the metal is not perfectly clear.

The foregoing fundamental principle, known as the distribution law, expresses the ratio between the concentration of a given element in the metal and its concentration in the surrounding atmosphere. The union of the metal with simple gas molecules will not in any way alter the applicability of the simple law. But as the law leads to conclusions strictly applicable to ideal gases, and as gases depart somewhat from the ideal, it may fail at times to express exactly the distribution of the elements between the metal and surroundings. However, departures from the ideal are not of serious consequence.

Hydrogen Solubility Varies

It was stated that the amount of gas absorbed by metals is dependent on the concentration of the gas in the surroundings; it is also dependent on the temperature. In most instances the solubility of hydrogen, oxygen and other gaseous elements in solid metals increases proportionally with the temperature up to the melting point. There is an abrupt increase when the metal liquefies and further increased solubility as the temperature rises.

To cite examples, the solubility of hydrogen in copper increases about three times at the melting point; molten silver dissolves about ten times its volume of oxygen and gives it up again on solidifying, and platinum behaves like silver. On the contrary, the solubility of hydrogen in palladium decreases abruptly (nearly one-half) as the metal melts. Whilst it does not necessarily follow, in metals the solubility of non-metallic elements generally increases with increasing temperatures.

There is complete absence of a linear relation between the solubility of a gaseous element in an alloy and its solubility in the component metals. Hydrogen, for example, is virtually insoluble in silver, yet alloying silver with palladium raises the solubility until a maximum is reached for an alloy containing 40 per cent. silver. At 130 deg. C. this alloy dissolves four times as much hydrogen as pure palladium.

The ability of an alloy to dissolve non-metallic elements is, then, not determinable from solubilities in the component metals. Due to the great number of alloying combinations which make up the industrial non-ferrous castings, the uncertainties governing solubility in alloys of an element such as hydrogen or oxygen become almost unlimited. Under the circumstances it is not at all surprising that there should be differences in the behaviour of alloys toward non-metallic elements, even when they are of the same general class. It is conceivable that average variations in compositions alone of some bronzes, brasses, aluminium, or die-casting alloys may at times be sufficient measurably to alter their contamination by non-metallic elements.

Methods for Controlling Solubility

Were it not for the fact that there are means for altering and controlling solubility, the problem of producing sound castings would be exceedingly difficult. In practice, for example, the tendency towards unsoundness in copper ingots and castings is kept in check either knowingly or unknowingly by a careful control of the oxygen content. This has two principal effects; first, it maintains the partial pressure of the hydrogen in the surrounding atmosphere below some fixed value, and second, it reduces the solubility of hydrogen in copper. Serious gas cavities occur only when the oxygen content of the metal falls below a certain quantity. This is because the amount of hydrogen absorbed by copper rises as the oxygen falls and rises very

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* Paper read before the American Foundrymen's Association at the International Congress at Philadelphia.

† Research Metallurgist, Battelle Memorial Institute.

‡ Yenson, T. D., and Herty, C. H., "Terminology Relating to Non-Metallic Elements in Metals," T. P. 555. "Metals Technology," June, 1934. Published by A.I.M.E.

rapidly with low oxygen content. Liberation of the hydrogen upon solidification, or the interaction between the hydrogen and copper oxide dissolved in the metal to form steam and its subsequent liberation, seems to account for the unsoundness in copper ingots or castings. An analogous mechanism would explain much of the unsoundness in other metals and their alloys.

From what has been said it becomes evident that the presence or absence of blowholes and porosity, of inclusions, and of sweating in non-ferrous castings, are closely tied in with the melting and casting procedure, and the deoxidation and gasification practice. The importance of controlling the furnace atmosphere, with its moisture and hydrogen contents, is certainly obvious.

In practice it is becoming more generally accepted that atmospheres either neutral or slightly oxidising to the metal or alloy in question are in the long run most satisfactory for melting. Reasons for this become apparent in the light of the inter-relation of the non-metallic element content of the metal to the composition of the surrounding atmosphere. Thus, for metals capable of absorbing quantities of hydrogen it may be advisable to maintain the furnace slightly oxidising to render the solubility of hydrogen in the metal as low as possible.

It does not follow from this, however, that reducing atmospheres are always detrimental in melting. Sound castings are being made daily from metal melted under the reducing atmospheres of electric furnaces. Conditions determine whether or not the reducing atmospheres will be detrimental. It is conceivable that an unusually dirty charge or one containing a high oxide content will be benefited through refining brought on as a result of chemical reduction of the impurities by the reducing gases. In addition, the principal reducing gas, carbon monoxide, is not soluble in some metals. Consequently, with the hydrogen content of the furnace atmosphere extremely low, so that it cannot contribute to the unsoundness, little or no harm may follow melting under reducing atmospheres.

Importance of Furnace Atmosphere

The foregoing emphasises the real importance of furnace atmosphere control in obtaining sound non-ferrous castings, whether the melting unit be heated by oil, gas, coke or electric power. Unfortunately, it is still impossible to prescribe methods of melting or types of furnace atmospheres that are generally applicable for the melting of all kinds of alloys. So much is governed by other factors, such as character of the scrap and charge, composition of the metal, humidity of the atmosphere, and type of melting equipment that, as yet, the judgment of the operators must be relied upon to establish wise melting procedures in their respective plants.

But it is not alone the melting procedure that must be controlled with care; there is also the interim from the moment the metal is taken from the furnace until it has solidified in the mould, when much harm may be done through gas absorption and oxidation, unless the metal is properly protected. Changes in environment—that is, surrounding the metal with a different atmosphere from what it was exposed in the furnace—immediately upset the balance established between the content of non-metallic elements of the metal and of the furnace atmosphere. Consequently, oxidation and gas absorption may be rapid when the metal is withdrawn from the furnace. Sometimes, within sand moulds, metal that has been melted with the greatest care is harmed by contact with moisture and other mould gases to the extent where the casting surface is honeycombed with small pinholes.

These phenomena relative to the solution of non-metallic elements during melting, preheating, pouring and solidification of the metal are all manifestations of that fundamental principle known as the distribution law. Recognition of this principle leads to the control of the non-metallic elements and the elimination of their harmful influences in non-ferrous metals.

Elimination of Harmful Influences on Non-Metallic Elements

It is the sudden change in solubility at the melting point, which causes gas to be given off during solidification, that accounts for porosity in castings due to dissolved non-metallic elements. To some degree the quantity of gas evolved depends on the rate of cooling. Because the gas is placed under pressure by the confining metal when it solidifies rapidly, it is possible to check blowhole formation by severely chilling the castings. This is because the solubility of non-metallic elements is a function of the pressure. Hence, to cast sound metal free from blowholes the hydrostatic pressure of the liquid metal should be kept greater than the greatest internal gas pressure.

This principle is interestingly illustrated by the perceptible reduction in zinc evolution from brasses by the presence of an aluminium film. The vapour pressure of zinc in brass is not greatly affected by the aluminium in the alloy. The skin of the molten alloy must therefore be under an appreciable stress in order that it may reduce the zinc loss.

It was mentioned that the solubility of hydrogen in copper, for instance, is greatly reduced by the presence of oxygen. Both tin and zinc will reduce the solubility of hydrogen, carbon monoxide, and sulphur dioxide in copper, and phosphorus probably acts similarly. By altering the composition of the metal it is possible, sometimes, to reduce the internal gas pressure substantially. This principle governs the action of some deoxidants, and they may be regarded as additions which reduce the internal gas pressure below that at which the gas is released. How low this pressure need be is not always easy to determine. In the case of hydrogen, for example, a certain amount of supersaturation appears necessary before bubbles will form.

One function of deoxidisers has been referred to; others are of equal importance. Certain deoxidisers alter the nature of the oxides, transforming soluble ones into insoluble ones that rise or form relatively harmful emulsions. The third important function is to free the metal of those easily-reduced oxides which react with certain components of the metal, during the latter's solidification, to form gaseous products. The reaction of copper oxide with hydrogen to form steam is one example. Here, the cause for porosity is the reaction between two soluble materials to produce an insoluble compound. The function of the deoxidiser is to remove the copper oxide, thus preventing the reaction from going forward.

Whilst it appears possible to remove hydrogen from non-ferrous metals by slight oxidation, attempts to do so may not be completely successful owing to the large excess of oxygen and length of time required for oxidation. The adjustment to equilibrium following changes in the composition of the surrounding atmosphere is slow, and more than equilibrium quantities of hydrogen may persist for some time. The velocity of reaction of this type, even at the temperature of molten metals, is slow.

Hydrogen Elimination by Pre-Solidification

By utilising the decreased solubility during solidification, more rapid reduction in hydrogen may be effected by pre-solidification, then remelting rapidly to the temperature for pouring the metal. This method has been successfully used on various non-ferrous alloy castings. Care must be taken, however, to see that the metal is not contaminated again during the reheating period. Other means, based on the principle of the distribution law, are available for eliminating the soluble non-metallic elements from metals. The principle is utilised when chlorine or nitrogen is continually bubbled through or swept over the surface of molten metal to eliminate dissolved gases, and again it is applied in the vacuum method of melting. To a degree, both methods have lately received stimulation.

The same may be said of the use of fluxes, their purpose being to protect the surface of metal from the furnace gases. Not all fluxes will protect the metal when highly heated. Many of them are easily penetrated by hydrogen. To be useful they should be impenetrable to hydrogen and should be capable of dissolving the oxides in the metal. While many schemes for eliminating the deleterious effects of non-metallic elements in non-ferrous castings are suggested, they are mostly dependent on such fundamental conceptions as the change in solubility of the non-metallic elements in metals with temperature, concentration and pressure, and, furthermore, upon the change in solubility on the addition of other impurities.

Cupola Practice and Carbon Control

(*Concluded from page* 172.)

Conclusions

And finally, it has been the aim to eliminate as many technicalities as possible in an effort to make a normally dry subject more interesting to those who have not had metallurgical training and to those also who have not had personal experience in cupola practice.

In closing, thanks are due to Mr. Brown, foundry superintendent, and the Austin Motor Company for permission to present this Paper, and for the encouragement and facilities given. To Mr. Sheehan, also, for his help, as it was he who made this Paper possible by instituting this method of melting control for production castings.

Vote of Thanks

Proposing a vote of thanks to Mr. Bamford, MR. N. C. BLYTHE called attention to the statement that a charge of only 500 lbs. was used in a cupola 40 in. in dia., and, further, that the amount of coke charged was insufficient to separate the metal charges. He would like to know, he said, why orthodoxy was departed from in this way. He (Mr. Blythe) was responsible for a continuous-casting plant, and he found that under such conditions it was necessary to make up their minds to do one of two things. Either they must operate the cupola efficiently and run the plant to the tune of the cupola, or run the cupola to the tune of the plant. Unless his mental picture of Mr. Bamford's conditions was wrong, a fluctuating demand for iron had to be met, and it would be interesting to know how Mr. Bamford took care of that fluctuation. Mr. Blythe added that it was seldom, in these highly-competitive days, that a firm was prepared for precise operating details to be made public in such a way that the audience could return to their jobs and start producing iron with a closer carbon control.

MR. E. C. DICKENSON seconded the vote of thanks, which was heartily accorded, and MR. BAMFORD acknowledged the compliment.

Solubility of Nitrogen in Liquid Iron

We append the conclusions given in the American Institute of Mining and Metallurgical Engineers' Technical Publication No. 591 on "Solubility of Nitrogen in Liquid Iron":—A simple method for determining the solubility of nitrogen in liquid iron has been devised. The solubility, at approximately 740 mm. pressure, was found to be 0.039 per cent. just above the melting point and 0.042 per cent. at 1.760 deg. C. Within the limits of experimental error, the solubility is not affected by 0.15 per cent. aluminium or by 0.70 per cent. silicon. The rate of solution of nitrogen in liquid iron is not greatly affected by temperature. The presence of aluminium or silicon in the melt exerts a very great influence upon the rate of solution, the rate coefficient being increased 10 or 20 fold in two experiments in which these elements were present.

Ingot Moulds, Bottoms and Slag Ladles

By J. BLAKISTON, A.I.Mech.E.

(*Concluded from page* 154.)

Metal

A similar metal should be used for all the preceding types of castings. Metal should be brought down from the cupola, so that it taps out at 1,450 deg. C., and allowed to stand in the ladle until the temperature drops to 1,250 deg. C. This generally necessitates the use of two ladles; pouring in all cases is done as quickly as possible, and with dry-sand moulds as hot as possible. It takes approximately 75 sec. to pour a 7-ton ingot mould, and 2 min. for a 10-ton ingot mould.

If bottom pouring is adopted on ingot moulds a slightly higher casting temperature is advisable, as a crust may form on the metal when half way up the mould through which the metal breaks, leaving a line of cleavage round the mould. This may be checked by allowing the runner to break into the mould at several heights. This method of running is probably ideal, but adds considerably to the cost of moulding.

Certain experiments were carried out at two foundries working on a similar class of mould to try to determine the ideal analysis for the hematite iron required for ingot moulds and ladles. A chart was made out—a horizontal line divided into 150 divisions, representing the lives of that number of moulds, and a vertical line representing the percentage of silicon and manganese present. The silicon and manganese contents of any moulds that had stood up to from 1 to 150 lives was seen at a glance. From the records of over 250 moulds it was found that the analysis, when within reasonable limitations, had no influence on the subsequent life of the mould. In some instances moulds of identical analysis gave 13 and 120 lives respectively. The best life recorded was given by an iron containing 1.45 per cent. silicon and 1 per cent. manganese. The best average life was given by metal containing 1.8 per cent. silicon and 1.2 per cent. manganese. One can therefore assume that the most suitable analysis for ingot moulds is the following:—Total carbon, 3.50 minimum; combined carbon, 0.50 maximum, silicon, 1.80; manganese, 1.20 maximum; sulphur, 0.03 maximum, and phosphorus, 0.06 per cent. maximum.

This should be obtained by blending equal proportions of two different makes of hematite, one high and one low in silicon. Small additions of steel scrap up to 5 per cent. are beneficial.

The blending tends to counteract the possibility of obtaining what is known as "off" or "dry" iron which the blast furnace periodically delivers, more so in these days of hard-driven blast furnaces.

There is no doubt that during the last few years there has been a marked deterioration in the physical quality of hematite iron pig. It used to be a difficult matter to break half a pig but now it merely has to be dropped on the ground. This defect can sometimes be remedied by superheating the metal, but, of course, this increases the coke consumption of the cupola considerably.

Experimental Variations in Metal Analysis

On the assumption that from 1.2 to 1.8 per cent. of manganese was detrimental to the life of a casting, experiments were conducted on ingot moulds bottoms with higher manganese content. Two per cent. of manganese was aimed at. This necessitated melting ferro-manganese in a separate cupola and adding it to the ladle. The lives of the bottoms made from this mixture showed a 25 per cent. increase in life, and were very promising, but the practice had to be discontinued owing to the punishment received by the cupola. Some 4-ton moulds were made in Austria containing 4.5 per cent. total carbon; these were made from charcoal iron, and were naturally very expensive, but the lives reported were from 350 to 400 casts, which are truly remarkable results.

As the supply of charcoal iron is strictly limited, it would pay to consider the possibilities of obtaining high carbon iron from other methods of manufacture, and continue experiments on these lines. There is a marked superiority in the reported lives of moulds on the Continent to those obtained in England, which it is very difficult to account for.

There is still a certain number of furnaces with hearths no larger than 8 ft. operating on the Continent, although they also possess some of the most modern and largest furnaces. The small furnaces may produce iron which has qualities impossible to obtain with the modern trend of blast furnace practice. The latest ingot stripping practices may also influence the lives of the ingot moulds. This discrepancy of lives of ingot moulds should be very closely investigated.

The time to determine when a mould has achieved its economic life is difficult to ascertain, and depends solely on the steel plant manager's opinion. Naturally a mould used on the poorer qualities of steel can be used much longer than moulds for special steel.

Fig. 9.—Typical Consignment of Castings for the Iron and Steel Industry.

Fig. 10.—General View of a Foundry catering for the Iron and Steel Industry.

Fig. 11.—Fettling Department of the Foundry shown in Fig. 10.

The subsequent treatment of ingot moulds in the steel plant is a big factor in their lives. They should be used continuously and not intermittently, if possible. Molten steel should not be poured into a stone cold mould. Hot moulds should not be cooled down by means of a hose pipe. If they must be cooled use water, certainly, but in the boiling form, immersing the whole mould in a tank of it. An ingot mould, although massive, is fragile, possessing considerable inertia. Therefore, it is not policy to drop it or bang one mould against another to dislodge a sticking ingot. If the ingot sticks owing to an irregularity forming on the inside the irregularity should be carefully chipped away by means of a pneumatic chipping hammer before the mould is again used.

In conclusion, it may be assumed that the biggest factor that determines the life of ingot moulds, bottoms and slag ladles is the subsequent care taken in the foundry after they are cast. The removal of any rigid core tackle, and careful, even cooling, combined with studied forethought as to the best mould and bottom design, all naturally have a big influence on the internal stresses. The above, combined with fair subsequent treatment in the steel plant to ensure that no fresh stresses are created, will go a long way to give these castings longer and more consistent lives.

DISCUSSION

MR. HACKWOOD said that Mr. Blakiston had stated in his Paper that bottom pouring was the ideal method. Could he say why, in his opinion, this was so?

MR. BLAKISTON said that bottom pouring obviated the liability of the metal striking on the side of the mould or core, which resulted in portions of the sand being washed into the casting. Also, there was no splashing and violent agitation while the mould was being filled. It had always been an accepted theory in foundry practice that a bottom-poured casting was generally better.

Jar Ramming Ingot Moulds

MR. BALLANTINE (Scottish Branch) disagreed with Mr. Blakiston on certain of his observations. He understood him to say they found the jar-ramming of ingot moulds unsatisfactory, and the methods of manufacture by hand and pneumatic ramming had superseded the machine, except in very small moulds. It might be interesting to know that the Fullwood Foundry, Mossend, successfully jolted up to 17 tons moulds weight. Also, they had a highly-mechanised plant, in which the sand is thoroughly controlled. No loam was used in either core or moulds and the main core iron as seen in the sections was entirely dispensed with. Moreover, this method held good on 35-ton moulds also.

Regarding the reference to "use" in the steelworks, he thought "abuse" might be a much more applicable term.

Mr. Blakiston, referring to the gentle immersion in water for cooling as a serious factor in longer lives as against the hose spraying, said that in one particular type of mould—a 6½-ton—which was supplied to two different works, of the same design, analysis, and the same controlled methods of manufacture, the immersion methods only give half the life of hose spraying.

Could Mr. Blakiston give any further information on lives of 350 to 400 in Austria, and, further, had he any experience in the use of chromium additions?

Mr. Blakiston's talk on bottoms was most interesting, especially when he mentioned top permanent parts giving as many as 100 casts with very little retouching. His foundry did likewise, but carried it considerably further than tops.

Factors Influencing Life

MR. BLAKISTON said his experience had been that in a foundry where every man was paid on output and keen to get as large an output as possible, the men showed a definite preference for hand-ramming, and could indeed maintain a higher output than with the machine. He might have been unfortunate in the choice of the machine.

As regards the "abuse" in the steelworks of ingot moulds, and Mr. Ballantine's experience of one plant getting a longer life, while taking no care of the moulds, and another plant getting a short life with the same mould while taking every care, probably the quality of steel in the two plants was different, which would account for this paradox.

Mr. Ballantine's method of moulding was ideal, and the elimination of the main core barrel would contribute greatly to an increased life of the mould. As regards the ingot mould produced in Austria, which gave 400 casts, the only information he had on this was taken from a German translation, and they were made from charcoal iron, and contained 4.5 per cent. total carbon.

For ingot-mould bottoms, he had tried numerous experiments on these with all types of ferro-alloy additions, such as chromium, vanadium, titanium, etc., casting them from both air furnaces and cupolas, but he never obtained results equal to good hematite with high-graphitic and low combined-carbon contents.

Casting Temperature

MR. N. D. RIDSDALE asked how the temperature of 1,250 deg. C. at which the iron was said to be poured was measured, since such a temperature seemed to be on the low side, and unless an immersion thermocouple had been used the temperature measurement would not be very accurate.

Why did Mr. Blakiston not continue to use the hematite containing 2 per cent. Mn for ingot-mould bottoms if this composition had been proved to be beneficial?

With regard to the composition of ingot moulds, it was understandable that a fairly considerable variation in silicon and manganese would not affect the life of the moulds nearly as much as the treatment it received in practice, but the condition of the carbon and the size and shape of the graphite flakes would probably have a considerable bearing on the life of the mould. Had Mr. Blakiston given much attention to this aspect of the subject, and had he taken photomicrographs to correlate the graphite structure with the behaviour of the moulds in practice?

Mr. Blakiston referred to some iron containing about 4.5 per cent. total carbon made in charcoal furnaces similar to that made in a small furnace in Cumberland. Would he explain what the characteristics are about this iron which made it good for ingot moulds? The Paper was undoubtedly a valuable contribution to the subject.

High Manganese and Cupola Costs

Mr. Blakiston, in reply, said that all temperatures were measured with a Cambridge optical pyrometer, which had been found most suitable for this purpose, although it is prone to the inaccuracies common to all optical instruments. The casting temperature may seem on the low side, but the extreme thicknesses of the castings permit this without any risk of cold runs. Naturally a bottom-teemed ingot mould would have to be cast at a higher temperature.

The experiment in high manganese was discontinued owing to the damage caused to the cupola lining when melting ferro-manganese. This naturally raised the cost of production.

He agreed with Mr. Ridsdale that the condition of the carbon had a big influence on the life of ingot moulds. The carbon should be practically entirely in the form of large graphite flakes. Test-pieces 2½ in. square were cast on all moulds, so that the foundry foreman could readily judge this condition by the appearance of, the fracture when they were broken off. Occasional micro-photographs were taken, but as these are liable to variation dependent on the method of polishing, more reliance is placed by the foundryman on the appearance of the fracture on the test-piece.

The influence of the carbon in its various forms might be easily illustrated by casting and machining piston rings. If the graphite flakes were broken up these rings had a considerable amount of spring. If the combined carbon be low and the graphite flakes large the metal became semi-plastic, and would remain in the position to which it is bent. This in his opinion was the ideal property for ingot mould material, and was one of the characteristics charcoal iron provided.

Sulphur Content

MR. ED. OWSTON asked if any special steps were taken to eliminate the sulphur in the ladle, as the figure of 0.03 per cent. seemed very low?

MR. BLAKISTON said that with such large amounts of metal being melted and the continuity of operation it was not difficult to keep the sulphur pick-up in the cupola low. An ingot foundry which consumes from 400 tons and upwards of hematite iron per week is more or less in a position to dictate to the iron manufacturers the quality of iron they require. If treatment for sulphur elimination was contemplated the tapping temperature of the cupola, viz., 1,450 deg. C., and its subsequent cooling period, offered an ideal opportunity for the treatment of the metal by means of soda ash; this, however, was rather a "dirty" procedure, and necessitated the use of teapot ladles to keep back the scum thus formed.

The Steel Manager's Viewpoint

MR. PEARSON, speaking from the point of view of a steel plant manager, agreed that a certain amount of abuse took place on a steel plant in handling ingot moulds, but this could not be avoided in the case of sticking ingots. He asked if Mr. Blakiston has had any experience in the manufacture of machined ingot moulds. He noticed on certain moulds received there was a tendency to hollowness at the top. Could this be avoided? Also there was a tendency for "growth" on certain castings. Mr. Blakiston referred to the advisability of having the moulds continuously in operation. He would like some explanation of what he meant by this.

MR. BLAKISTON said that certain ingot moulds had been made with machined barrels for casting special ingots for tube steel; the machined mould, however, did not last so long as the unmachined one. Evidently the skin of the casting formed a protective layer. The hollowness on the top of the mould could be definitely remedied in the foundry by feeding or filling the hollow with metal immediately after the mould has set. As the mould generally failed at the bottom, it is thought that these hollows at the top should not affect the life of the mould.

Regarding "growth," a fortune awaited the person who could produce an iron that would not grow at high temperature. Four per cent. chrome addition tended to check the growth, but the iron produced has a high contraction, was exceptionally hard and brittle, and would not be at all suitable for ingot moulds. By continuity of operation, he meant the moulds should be kept in operation so as not to allow them to become stone-cold. They should not be exposed to the weather in between usages, as this caused them to rust and any minute cracks to open out further, and so the life of the mould was materially shortened by corrosion stresses—a point which was often overlooked.

"Aquadag" Lubricant

A recent issue of the Acheson Technical Bulletin (published by Messrs. E. G. Acheson, Limited, of London), points out that "Aquadag," one of the firm's products, is a concentrated preparation containing approximately 18 per cent. by weight of electric-furnace graphite dispersed in distilled water, which is used as a lubricant in places where oil is either objectionable or dangerous and as a die lubricant in drawing tungsten and molybdenum.

Defects in Steel Castings

SHEFFIELD FOUNDRYMEN'S VIEWS

Following Mr. C. Howell Kain's interesting lecture which appeared in our issue of February 21, 1935, a thoroughly practical discussion ensued from which we have abstracted the chief features.

Entrapped Air

The Chairman (Mr. J. E. Hurst) opening the discussion, said that he was particularly interested in what Mr. Kain had said about the question of the entrapped air buffer on the boss at the extremity of one of the castings he had dealt with. The air buffer was apparently drawn from it in the shape of a pipe. He was not sure whether he understood Mr. Kain correctly when he was explaining his own theory on the subject, but he understood him to say that his theories had undergone a certain amount of modification in the light of sand testing. Apparently, Mr. Kain had experienced some difficulty with sand. As he understood it Mr. Kain experienced difficulty with sand of a high-permeability number. He would like to know if he (Mr. Hurst) interpreted Mr. Kain's remarks correctly when he assumed him to mean that the difficulty alluded to was minimised when the sand was of a lower permeability number. If that was so it fitted in with some experiences of his own in regard to newer alloyed cast irons that had shrinkage values similar to steel. He had definitely found that with very fine-grained sand they were getting much better results than they had got when using sands of a very open nature. He had not been able to account for it, but it was a fact that they obtained greater freedom from those cavities, whether they were entrapped areas or shrinkage cavities. He would like Mr. Kain to give them a little more information on that point.

Mould Drag

Mr. F. E. Steele said he was very interested in the question of mould drag, especially in regard to thin castings. He definitely attributed to mould drag a great many of the difficulties they had experienced in the running of thin castings, either in steel or cast iron, more especially in regard to green-sand moulding. One thing that impressed him was the pressure exerted in front of the stream of steel or iron, as the case might be, and he agreed with Mr. Kain that this was a very vital point. In his view, if they could reduce that back pressure, they would be going a long way at any rate towards removing some of the difficulties of the internal cavities. Shrinkages, of course, they found more in steel than in cast iron, but even in cast iron they found internal shrinkages. He thought that Mr. Kain would probably agree that those internal shrinkages very often were not due to the structure of the material used so much as to the fact that the air generated inside the mould collected there and could not release itself. Moreover, he thought that in many cases the forming of cavities could be overcome by the method of pouring. For instance, if they poured a mould, say 18 in. from the runner, and then poured the same mould only 6 in. from the runner, it was his belief that they would be tending to draw in from the atmosphere air that would eventually go into the casting.

Sand Permeability Requirements

Mr. Kain said the casting that Mr. Hurst had mentioned consisted essentially of a large boss with a branch on it and a small boss attached. He apologised if he had not made himself quite clear on this. The cavity was perfectly round and smooth. The trouble described was first noted before any sand testing at all was done in this country. They were then using a very coarse silica sand from Leighton Buzzard which had a permeability of considerably over 300—probably 400. Undoubtedly the trouble was less with a lower permeable sand. In his opinion they would require a closeness of about 160 in steel casting sand. With sand below that figure they seemed to have trouble. He apologised to Mr. Steele for not talking much about mould-drag. Undoubtedly mould drag was a serious matter, particularly with thin steel castings. It certainly caused cracks to form. The friction of the castings against the sand was very much greater than was often realised. Sometimes it was found that the runner was actually pulled away from its normal position. This meant that the bulk of the contraction had been away from the runner instead of, as was usually supposed, towards it. He did not know that the mould drag was more serious with green sand than dry sand mould. In fact his experience was rather in the contrary direction. He agreed with Mr. Steele that the question of the metal flowing down the runner was not seriously considered, or at least not as much as it ought to be. A casting which in grey iron would normally be run in a matter of 55 to 60 seconds, in steel would commonly be poured in 6 or 7 seconds, and the pouring velocity must accordingly be correspondingly higher.

Mr. G. Offiler said the points put forward were new to him and certainly must be considered along with the mould criticism put forward from time to time. The drag appeared widely on the surface of the casting as shown in Mr. Kain's illustration. It was very puzzling as to why this should be so.

Mould Drag and Surface

Mr. Kain said that undoubtedly Papers on steel casting for many years had not produced anything new. For this reason they had rather marked time as compared with those who gave Papers on grey-iron and non-ferrous metals. It was not the case that roughness in steel castings was due to the drag. It was due to the inferiority of the sand, to the excessive heat of the metal or something like that, and the drag was accentuated by the roughness of the casting. Even in the case of a perfectly smooth casting and one which had an excellent casting skin, the lag was very pronounced. In some instances he had found castings, 4 or 5 ft. long, with a perfectly smooth skin cracked for no apparent reason. The only possible explanation was that there had been friction between the metal and the mould.

Contraction of Steel Castings

Mr. E. J. Brown said, in connection with Mr. Kain's remarks, a series of American Papers had just been issued, among which was one by Briggs and Gezelius on "Free and Hindered Contraction of Carbon Steel." This Paper was, in the speaker's opinion, something of a classic, and should be of theoretical interest to all steel foundrymen. The chief points which would appear to emerge from the experiments which had been conducted were:—(1) Contraction decreases as the carbon content increases. If, however, contraction should be hindered, as is possible in the case of castings, the carbon content has little effect; (2) majority of the contraction takes place before the critical range is reached; and (3) by preventing freedom of contraction, that is, by restraining, using springs for the purpose, the linear contraction was reduced from about 2.5 to 0.5 per cent., apparently without fracture.

He (Mr. Brown) mentioned this latter point in order to point out that, after all, there seemed to be a fair amount of flexibility before fracture takes place, due to contraction. With regard to Mr. Kain's test-bar experiments, it was obvious that the best ductility figures were obtained from the portion of the bar which was quickest to cool. He did not wholly agree with Mr. Kain's reasoning on the matter, but was inclined to the view that the variable results obtained were the result of the influence of non-metallic inclusions.

Carbon Content and Contraction

Mr. Kain agreed that the Paper by Briggs and Gezelius on the contraction and solidification of steel castings was undoubtedly a classic. He did not think he could agree entirely with the deduction of Briggs and Gezelius as to the contraction becoming increasingly less with increase of carbon in the steel casting. He thought it was so small as to be negligible. In ordinary steel castings up to perhaps 0.55 or 0.60 per cent. C.—ignoring the special high-alloy steels—the contraction differences were remarkably small. He agreed with Mr. Brown's explanation of the better results obtained on the bottom bars of a test-block. They did give better results and consisted entirely of primary crystals. As they formed the crystals tended to drive inclusions before them.

Recommend Permeability

Mr. T. R. Walker said he did not think he agreed entirely with Mr. Kain's remarks about non-metallic inclusions. It was, of course, a fact that primary crystals would drive inclusions in front of them, but it was also known that the lower half of an ingot was precisely the place where they would find most metallic inclusions. This had been established by the Iron and Steel Institute beyond doubt. He was interested in Mr. Kain's remarks about the properties of his sand, and agreed that 200 to 300 was a very good permeability number for general green-sand work. The practice of those with whom he was associated was to run about 220 to 270, but in some heavier castings it was necessary to go below that and below Mr. Kain's 160, and in these cases they found they could get quite good results with sand having a permeability number of 130, or even 120.

Incidence of Water Vapour

Mr. Kain said he could not say with certainty that in any of the test-bars to which he had referred he had troubles that he could directly attribute to non-metallic inclusions. What he had suggested was that that action did take place and was, perhaps, a contributory cause. He was not prepared to say that that action took place to any pronounced extent. He merely suggested it as a possible explanation. The figure of 160 he had quoted was for permeability of green sand only, and he took it that the larger castings to which Mr. Walker had alluded were dry. Unfortunately he (Mr. Kain) did not know what the properties of dry sand were.

With regard to the possibility of low gas pressure in the mould cavity, Mr. Kain said that this might be caused by the rapid condensation of water vapour which always took place a short distance back from the mould face.

Cracks on Corners

Mr. C. J. Dadswell said he was interested to hear Mr. Kain's theory in regard to cracks on corners. He himself gave a Paper recently and put forward exactly the same theory—that the cracks one found at corners had been caused by the penetration of material into the steel from the strongly heated corner sand, the sand becoming excessively heated because there were two right angles. Many of the faults were due, as Mr. Kain had said, to the effect of trapped gas.

Mr. Kain said that they were often deceived by the fact that the little cavities that appeared to be cracks had sharp chipped angles. This was due to the gas forcing its way in when the metal was in a partially frozen state. This could

(*Concluded on page* 178.)

This Week's News in Brief

Trade Talk

IT IS STATED that orders for £200,000 worth of machine-shop equipment will be placed with British firms as the result of the annual meeting of the Chinese Government's Purchasing Commission, which was held on Monday.

A METAL INDUSTRIES EXHIBITION is to be held at Osaka, Japan, from May 10 to 31, 1935, under the joint auspices of A.G.N.E. (publishers of the "Japanese Journal of Metals") and the Nikkan Kogyo Shinbun-sha (the "Daily Industrial News"). The exhibition will be the largest ever held in Japan.

MEETINGS OF THE SHAREHOLDERS of Messrs. Crossley Bros., Limited, gas- and oil-engine manufacturers, of Manchester, have been called for March 19 to consider proposals for a reconstruction of capital. It is proposed to write down assets by approximately £250,000 by reducing the ordinary shares from 10s. to 5s. a share.

THE BLAST-FURNACE DEPARTMENT of the Zaporozhstal metallurgical plant in Kichkas, Dniepropetrovsk Province, U.S.S.R., is at present fulfilling a large order for 100,000 tons of pig-iron for export. This plant was the first in the Union to produce pig-iron for export. Samples of this pig-iron have been sent to an exhibition in Lyons, France. Exhibits will also be on view in the Central Museum of Soviet Export in Moscow.

IT IS REPORTED that another important order for rolling-stock has been received by Messrs. R. Y. Pickering & Company, Limited, Wishaw. The order is for a considerable number of covered goods wagons fitted with vacuum brakes, the construction of which will involve many months' employment for a number of men. This is in addition to the order for railway coaches to the value of £100,000 placed by the L.N.E.R. recently.

THE SHIPYARDS OF Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, including two at Walker-on-Tyne and one at Willington Quay, are to be sold by public auction on March 25 and the four following days, by order of National Shipbuilders' Security, Limited. The yards, which have been in the hands of National Shipbuilders' Security, Limited, since last July, were capable of an annual output of 100,000 tons.

MESSRS. JOHN LEWIS & SONS, LIMITED, Torry shipyard, Aberdeen, have received an order for a specially-designed hull for a steel-screw trawler. The vessel is for Mr. W. A. White, of White's Marine Engineering Company, Limited, Hebburn-on-Tyne. The machinery to be installed will be the White patent combined reciprocating engine and exhaust steam turbine. The hull will have a streamline stern and new form of bow and patent reaction rudder.

AT THE SIXTEENTH annual social gathering of the employees of Messrs. John G. Stein & Company, Limited, held in Falkirk, Colonel Alan Stein, who presided, said, in the course of a review of the work of the past year, that there were 180 more employees than at the same time last year. With regard to trade prospects, Colonel Stein said that there had been a marked revival in the steel industry, and the brick trade had benefited. The past year had been a record one for the firm.

CONSTRUCTION AND ERECTING WORK on the second blast furnace in the Krivoi Rog Metallurgical Combine, Russia, the 116th furnace of its kind in the U.S.S.R., is approaching completion. Tests will begin in the middle of March, and it is expected that the furnace will be blown in April. Its daily production capacity will be approximately 900 tons of iron. Work on the third blast furnace, to be one of the largest not only in the Soviet Union, but in the world, will begin in the middle of this year.

AN EMPIRE EXHIBITION on a most comprehensive scale, and of a scope and character comparable to the great Wembley Exhibition of 1924-25, will be held in Johannesburg during the concluding months of 1936. The undertaking has the strong financial support of the Government of the Union of South Africa, and invitations to participate have been sent to the various Governments of the British Empire. Commercial exhibits from all parts of the Empire will be accepted. The London office of the Exhibition is at 21, Tothill Street, London, S.W.1.

MESSRS. J. GRAY & SONS, LIMITED, of 5, Victoria Street, London, S.W.1, have recently shipped enamelling plant to France and India, and have just completed the shipment of a complete enamelling plant to China, the equipment comprising an enamelling muffle furnace, charging machine, grinding mills, pickling equipment, spray booths, and all the necessary tools and accessories. Their British-made enamels are also finding favour abroad, and are being distributed to enamelling firms in Holland, Jugo-Slavia, Australia, New Zealand and China.

Contracts Open

Preston, March 14.—Cast-iron special pipes and castings, for the Waterworks. The Water Engineer, Municipal Building, Preston. (Fee £1 1s., returnable.)

Argentina, March 22.—Five horizontal duplex pumps, petrol driven, for the Argentine State Oilfields. The Department of Overseas Trade. (Reference G.Y. 14,832.)

Edinburgh, March 13.—600 tons of 16-in. dia. cast-iron pipes, lined with concrete, for the Town Council. Messrs. J. & A. Leslie & Reid, 29, Waterloo Place, Edinburgh.

Worksop, March 11.—1,668 yds. of 3-in. and 1,989 yds. of 4-in. cast-iron pipes, for the Rural District Council. The Surveyor, Council Offices, Highfield House, Carlton Road, Worksop.

Ely, March 18.—2,100 yds. of 4-in. spun cast-iron pipes, together with valves, hydrants, etc., for the Urban District Council. The Surveyor, Urban Council Offices, Ely, Cambs. (Fee £1 1s., returnable.)

Cardiff, March 13.—Two oil-engine-driven and one electrically-driven main sewage pumping units, capacity 200,000 galls. per hr. each, with accessories, piping, etc., for the Town Council. Mr. G. H. Whitaker, city engineer, City Hall, Cardiff.

Southampton.—Supply and erection of two pumping units, consisting of centrifugal pumps driven by steam turbines, for the Town Council. Mr. J. Hawksley, waterworks engineer and manager, Civic Centre, Southampton. (Fee £3 3s., returnable.)

Penrith, March 25.—Providing and laying, with valves, specials and valve chambers, the following water main in spun-iron pipes:—¼ mile of 7-in., three miles of 6-in., four miles of 5-in., three miles of 4-in., 32 miles of 3-in.; also two miles in 2-in. dia. vertically cast-iron pipes, for the Rural District Council. Messrs. J. J. Davison & Partners, civil engineers, 6, King Street, Wigton, Cumberland. (Fee £3 3s., returnable.)

Company Reports

James Booth & Company (1915), Limited.—Net profit, £53,656; brought in, £19,964; ordinary dividend of 15 per cent.; to reserve, £15,000; carried forward, £20,877.

Clarke, Chapman & Company, Limited.—Net profit, £29,938; brought in, £720; preference dividends, £3,789; distribution of 5 per cent. on the ordinary shares, £17,692; carried forward, £9,178.

Vickers, Limited.—Final dividends of 2½ per cent. on the preferred 5 per cent. stock and on the 5 per cent. preference shares (both less tax), and 2½ per cent. on the cumulative preference shares (free of tax).

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Pump Unit, Limited, 62, Oxford Street, London, W.1.—Capital £100. Engineers, iron founders and toolmakers.

F. E. Rowland & Company, Limited, Climax Works, Reddish, Stockport.—Capital £5,000. Machine-tool manufacturers. Director: F. E. Rowland.

Macmillan Foundries, Limited, Cassiobury Mills, St. Albans Road, Watford.—Capital £600. Brass, aluminium and iron founders. Directors: D. G. Macmillan, N. G. Macmillan and P. D. Macmillan.

Personal

MR. ALFRED HODGSON, of Canal Foundry, Victoria Street, Openshaw, Manchester, has been appointed honorary treasurer of the National Ironfounding Employers' Federation.

MR. F. A. HARPER, who recently resigned the honorary secretaryship of the Middlesbrough Branch of the Institute of British Foundrymen, has been presented by the members of the Branch with a modern oak bureau and a silver cigarette case, as a token of their appreciation of his services during the past five years. Mr. Harper's new address, as and from March 5, will be 2, Balmain Road, Davyhulme, Manchester.

EX-PROVOST JACKSON, Grangemouth, chairman and managing director of the Grangemouth Dockyard Company, Limited, has just completed his fiftieth year of service with the firm. Previous to going to Grangemouth he was with Messrs. Harland & Wolff, Limited, Belfast, and with Sir John Arnott at Passage West, Co. Cork. During the past week he was entertained by his present directors and staff in honour of the occasion.

MR. AND MRS. ALEXANDER MITCHELL, of Bonnybridge, have celebrated the fiftieth anniversary of their marriage. Mr. Mitchell, who is 74 years of age, is a well-known figure in ironfounding circles, having been associated with the industry during the whole of his life. He began work at the age of 14 with Messrs. Smith & Wellstood, Limited, and is looking forward to celebrating his 60th anniversary in the service of the firm in August next. For the past 17 years Mr. Mitchell has been secretary of the firm, while he is also a director of Mitchell, Russell & Company, Limited, Chattan Foundry, Bonnybridge. The office and works staffs of Messrs. Mitchell, Russell & Company, Limited, offered congratulations and, through the medium of Mr. G. Dearie Russell, O.B.E., chairman of directors, made presentations to Mr. and Mrs. Mitchell.

Obituary

SIR H. LINCOLN TANGYE died in London on Sunday, February 24, aged 69. He was the son of the late Sir Richard Tangye, the Cornish inventor and engineer, who, with his brother George, founded the well-known Birmingham firm of Tangyes, Limited, engineers and ironfounders. Sir H. L. Tangye was vice-chairman of the company.

MR. STANLEY R. PATTERSON, of Porthcawl, formerly chief engineer at the Dowlais Works of Messrs. Guest, Keen & Nettlefolds, Limited, died recently, aged 51. When those works were transferred to the British (Guest Keen Baldwins) Iron & Steel Company, Limited, Mr. Patterson was transferred to Port Talbot. He was largely responsible for the lay-out of the new Dowlais Works at Cardiff, at present under construction.

MR. FRANCIS HENRY VERRILL, who was managing director of the shipbuilding firm of Messrs. Richardson, Duck & Company, Limited, Thornaby-on-Tees, has died at Eaglescliffe, Darlington, aged 60. He joined the firm as a junior clerk, and rose to managing director, a position he held until the company went into liquidation. Later he and others started the South Stockton Shipbreaking Company, Limited, on the site of the former shipyard. He was a director of this new concern.

Defects in Steel Castings

(Concluded from page 177.)

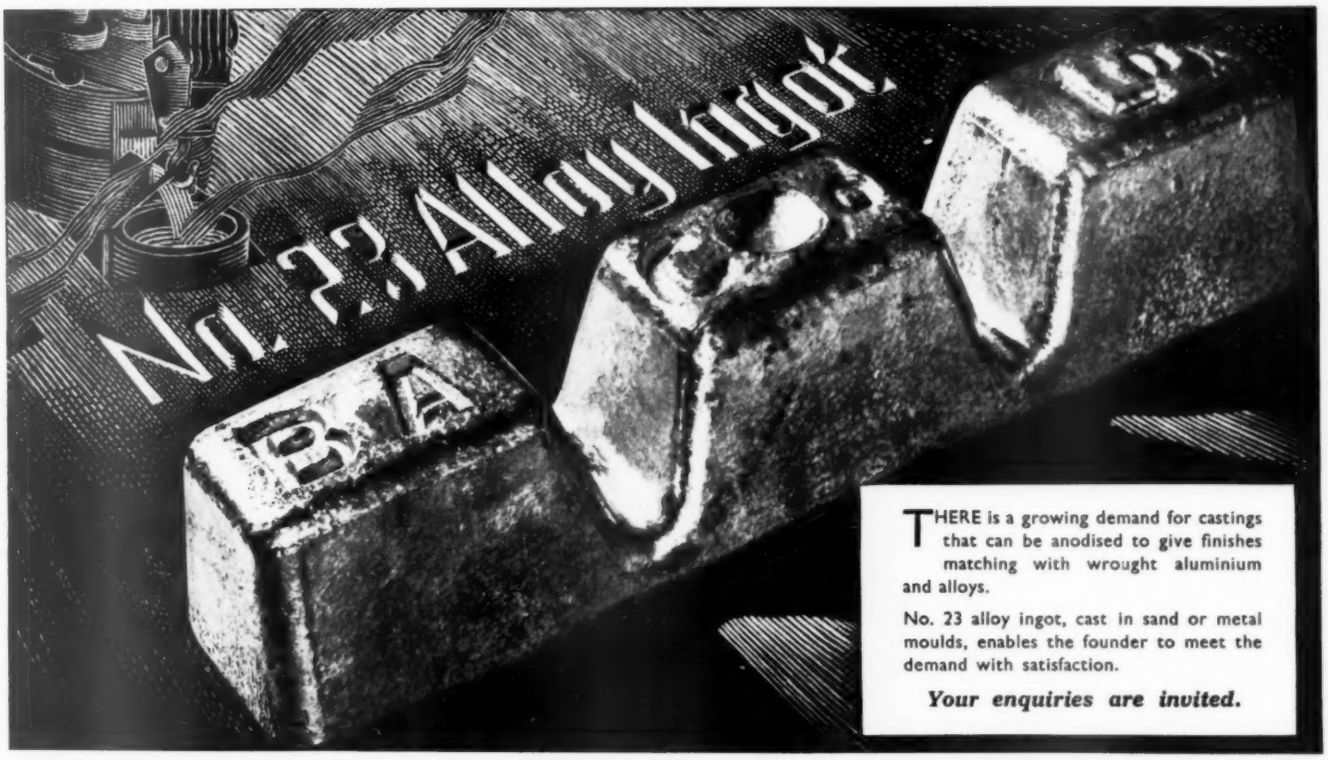
be very efficiently overcome by reversing the casting and feeding it on the top, or better still by doing away with some of the sand altogether.

DR. J. G. A. SKERL remarked that it seemed to him that a great many of the troubles which Mr. Kain had indicated were due to the effect of the solubility of oxygen and steel. It was a fact that metal seemed to flow better in a green sand mould than in a dry sand mould.

MR. KAIN said he was grateful to Dr. Skerl for his suggestion as to the probable cause of the flow of steel in the case of green sand.

MR. A. V. GODDARD proposed a vote of thanks to Mr. Kain. This was seconded by MR. A. WHITELEY and carried unanimously.

XUM



THERE is a growing demand for castings that can be anodised to give finishes matching with wrought aluminium and alloys.

No. 23 alloy ingot, cast in sand or metal moulds, enables the founder to meet the demand with satisfaction.

Your enquiries are invited.

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2 in.—12 in. & CONNECTIONS. to 24 in. dia.

WE HAVE FIFTY-TWO YEARS OF ACCUMULATED EXPERIENCE AND METAL PATTERNS.

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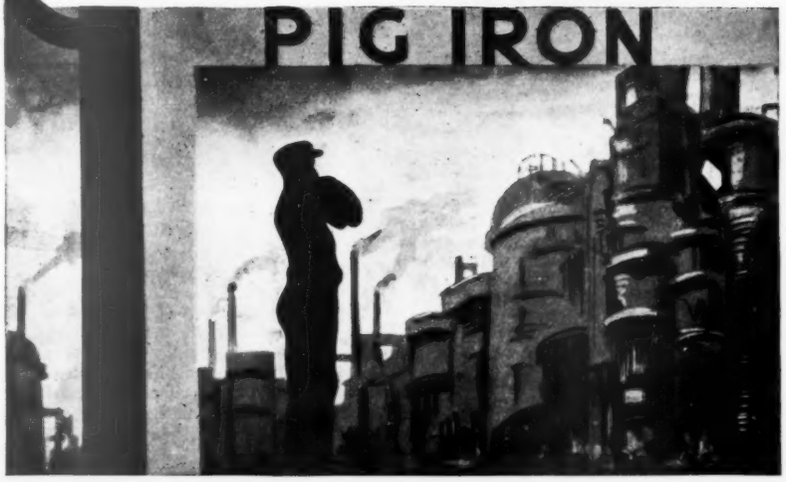
COLVILLES

PIG IRON



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HIGH GRADE HEMATITE PIG IRON

SPECIAL & ORDINARY FOUNDRY QUALITIES & FORGE

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Raw Material Markets

Activity in the iron and steel trades has not yet recovered from the lassitude which set in at the beginning of the year, new business being particularly lacking in the steel market. More orders are beginning to circulate, however, and it is expected that the volume of trade will soon resume its normal level. Meanwhile, heavy tonnages are being taken out against existing contracts, especially of pig-iron. The outlook in the export trade is not so satisfactory, Italy being the latest addition to the long list of foreign countries which have imposed severe import restrictions.

Pig-Iron

MIDDLESBROUGH.—The Cleveland iron market is particularly perturbed by the new Italian import restrictions. Last year Italy was the largest foreign buyer of pig-iron from this area, shipments averaging about 1,000 tons per month, whilst January clearances exceeded 3,000 tons. Fortunately, there is a good home demand for Cleveland iron, and producers have no misgivings on that score. Export prices are substantially below the fixed minimum figures quoted to British buyers, who are paying 67s. 6d. per ton for No. 3 Cleveland G.M.B. foundry grade delivered in the Middlesbrough area, 70s. for No. 1 foundry iron and 66s. 6d. for No. 4 foundry and No. 4 forge. Delivered prices of No. 3 G.M.B. in other areas are:—North-East Coast, 69s. 6d. per ton; Falkirk, 67s. 3d.; Glasgow, 70s. 3d.

LANCASHIRE.—Deliveries of foundry iron to Lancashire consumers against existing contracts are maintained at a steady level. Current trading is still limited, but a revival is expected towards the end of the month, when a number of contracts will be running out. Offers of Staffordshire, Derbyshire and Lancashire brands of No. 3 equal to Derbyshire, for delivery to Lancashire foundries, are on the basis of 74s. per ton, Northants at 72s. 6d., Scottish No. 3 at from 81s. 6d. to 82s. 6d., East Coast hematite at from 75s. to 76s., according to grade, and West Coast hematite at about 78s.

MIDLANDS.—Dealing in pig-iron is rather quiet at the moment. Many of the larger ironfounders are still off the market, being covered either to the end of the month or in some cases to the end of the half-year. There was a meeting of the Central Pig-iron Producers' Association last week, but no changes in prices were made. None was expected. The controlled prices for Midland brands of ordinary foundry iron are 67s. 6d. per ton for Northants No. 3 and 71s. for Derbyshire, Staffordshire and Lincolnshire No. 3, delivered Birmingham and Black Country stations, and subject to a graduated rebate to large consumers. Low-phosphorus pig-iron is quoted at from 85s. to 87s. 6d., Scottish at 85s., and medium-phosphorus at from 72s. to 80s., while for engine and similar work where refined iron is wanted quotations range from £5 7s. 6d. per ton delivered to the Midland area.

SCOTLAND.—There is a disappointing lull in the demand for foundry iron on the Glasgow market, the smaller foundries experiencing a scarcity of work, excepting those engaged in the light-castings trade. There is no change to report in prices and Scottish No. 3 foundry is still quoted at the official minimum of 70s. f.o.t. furnaces, with 2s. 6d. extra for No. 1. The official prices of No. 3 Cleveland are still unchanged at 67s. 3d. f.o.t. Falkirk and 70s. 3d. f.o.t. Glasgow, with other English foundry iron quoted at 1s. 3d. per ton below these figures.

Coke

Conditions in the coke market show no change, the majority of users being already well contracted. Prices are unaltered at 36s. to 40s. for best Durham coke, Welsh from 34s. to 45s., according to analysis, and Scottish from 40s. to 41s. per ton delivered Midland points.

Steel

Following a period of quietness, business is showing signs of greater activity. The volume of inquiry in most departments of the market has increased and a fair proportion has matured into actual business. This movement has encouraged hopes that the usual spring demand is beginning to develop. The recent improvement in the demand for semi-finished steel has been maintained and a fair volume of orders is reaching the producers. Purchases of Continental semis have been on a comparatively small scale, but deliveries are still being received against old contracts. The production by the British manufacturers is held at a high rate and consumers are showing rather more interest in forward business. In the finished-steel department, active conditions rule, and most producing works carry a good tonnage of orders on their books. The demand from home users remains active, but export business lately has been rather poor.

Scrap

Cast-iron scrap is generally in active request. In the Cleveland district, both heavy machinery metal and ordinary foundry cast iron are in strong demand at 55s. and 53s. per ton respectively. The scrap-iron market is very firm in the Midlands, where local ironfounders are offering 55s. to 57s. 6d. for heavy machinery scrap in handy pieces, 50s. to 52s. 6d. for good heavy pipe and plate scrap, and 47s. 6d. for clean light metal. Good supplies of scrap are available in Scotland, where heavy machinery grade is quoted at 56s., with ordinary cast-iron scrap at 51s 3d. In South Wales, the demand for scrap is still very limited, and prices have an uncertain tendency.

Metals

Copper.—As suggested last week, the recent fall in copper quotations appears to have had a speeding-up effect on the negotiations for international control of copper production. At all events, representatives of Rhodesian, Belgian Congo and European producers are now arriving in New York for the long-postponed conference, which will, it is reported, open to-morrow (Friday). The news of their sailing had a cheering effect on the copper market, which has now a rather stronger tone. The continued weakness of sterling has also played its part in the increase in copper prices on the London market. The exchange factor is an important one, since a large proportion of our copper imports comes from America.

"Copper was firmer on the news that the European producers had been invited to join in a conference with the American producers next week. We believe that the outline of the proposal will be a 15 to 20 per cent. curtailment with some restrictions on American exports to Europe, and that one of the big companies which produces copper as a by-product will store excess production for the time being," report Messrs. Brandeis, Goldschmidt.

Daily quotations :—

Cash.—Thursday, £27 7s. 6d. to £27 8s. 9d.; Friday, £27 17s. 6d. to £27 18s. 9d.; Monday, £28 7s. 6d. to £28 8s. 9d.; Tuesday, £28 1s. 3d. to £28 2s. 6d.; Wednesday, £28 to £28 1s. 3d.

Three Months. — Thursday, £27 15s. to £27 16s. 3d.; Friday, £28 3s. 9d. to £28 5s.; Monday, £28 15s. to £28 16s. 3d.; Tuesday, £28 8s. 9d. to £28 10s.; Wednesday, £28 6s. 3d. to £28 7s. 6d.

Tin.—The low price to which tin fell last week drew out a large amount of purchasing by consumers and others, with the result that quotations have now recovered somewhat.

Although the outlook is still rather uncertain, rather more confidence was shown following the publication of the February statistics. These showed an increase in "total visible supplies," but as this increase was more than accounted for by bringing into account "buffer pool" stocks, which have previously been left out of the reckoning, the statistical position has actually shown a slight improvement.

Market fluctuations :—

Cash.—Thursday, £215 to £216; Friday, £220 to £220 5s.; Monday, £219 10s. to £220; Tuesday, £218 10s. to £218 12s. 6d.; Wednesday, £215 5s. to £215 15s.

Three Months.—Thursday, £211 10s. to £211 15s.; Friday, £215 5s. to £215 10s.; Monday, £215 5s. to £215 10s.; Tuesday, £213 12s. 6d. to £213 17s. 6d.; Wednesday, £212 to £212 10s.

Spelter.—The zinc market has a slightly firmer tone. In the aggregate, there is quite a good demand from consumers in this country, although the export trade in galvanised sheets remains very depressed. No information is yet forthcoming regarding the official investigation into the effects of the import duty on foreign metal.

Official quotations :—

Ordinary.—Thursday, £11 8s. 9d.; Friday, £11 7s. 6d.; Monday, £11 11s. 3d.; Tuesday, £11 10s.; Wednesday, £11 10s.

Lead.—The price of lead pursues a very even course, revealing nothing of the disturbance that has taken place in other commodity markets. There is a steady and satisfactory demand from the consuming trades in this country.

Day-to-day prices :—

Soft Foreign (Prompt).—Thursday, £10 6s. 3d.; Friday, £10 5s.; Monday, £10 6s. 3d.; Tuesday, £10 5s.; Wednesday, £10 6s. 3d.

Welding Research

The Report of Council, submitted at the annual meeting of the Institution of Mechanical Engineers held in London recently, states that Prof. J. H. Andrew and Mr. H. E. Davies, in the Metallurgy Department of the University of Sheffield, have been carrying out an organised research on the nitrogen absorption of weld metals, the photographic and micrographic examination of welds, and the hardness distributions in weld metal. The tests have shown that while low-temperature annealing may remove stresses in the metal, it brings about an undesirable segregation of carbide to the grain boundaries and appears to cause a precipitation of nitride from solid solution. The researches have shown the variation of carbon content in the different layers of welds and the difficulty, therefore, of finding a suitable normalising temperature for the refinement of every layer.

In the Brown-Firth Research Laboratories, Dr. W. H. Hatfield, has carried out tests on the corrodibility of welds, and a preliminary report of this work has been submitted to the Committee.

Members have presented to the Committee notes dealing with the following specialised aspects of the research: an experiment to study the simultaneous cyclic variations of stress and temperature and their effect upon a weld; stresses in boiler drums; periodicity of severe pressure alternations in boiler drums in service; hammer treatment of welds. It is hoped to embody these in a formal Report.

At the University of Sheffield the machining of all the specimens used has been carried out, necessitating the continuous employment of lathes, milling and other machines throughout the year. The researches being carried out in the Engineering Department of the University of Sheffield include: the effect of heat-treatment on impact value at various temperatures; the comparison of impact values of welds obtained from different electrodes; the time-embrittlement of welds when heated for long periods at various temperatures; the age-embrittlement of welds at room temperature after sudden cooling from certain temperatures; short-time tensile tests to determine the breaking strength, percentage elongation and percentage reduction of area, apparent modulus of elasticity, limit of proportionality, and stresses at which small creeps can be observed; long-time creeps tests under constant stress; hardness measurements of a weld as a test of overstrain, and repetition stress tests on welds.

These have been carried out on weld specimens, prepared by different works, in four different machines. One of the machines has been specially designed to carry out tests on welded-plate specimens at normal and at high temperatures. For the high-temperature tests a specimen about 9 in. long is enclosed in an electrically-heated furnace, the weld being at the centre of the furnace. Cycles of bending stress are superimposed upon the specimen, a length of 11 in., including the 9 in. within the furnace, being subjected to constant bending moment.

BRITISH REMA

Blacking Wash Mixer.

Produces 40 gallons of high grade facing material in 15 minutes.

ADVANTAGES—

Thoroughly mixed material.

Uniform mixture ensures mould faces being covered evenly.

Mixture can be drawn off as required from either tank.

Built in a wide range of sizes to suit large or small foundries.

BRITISH REMA Pulverised Fuel Firing also will interest you. Send for catalogue.

The British Rema Mfg. Co., Ltd.,
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LONDON REPRESENTATIVE :
P. G. Ryder, First Avenue House, High Holborn, W.C.1.

British Rema No. 1 size double tank centrifugal mixing and emulsifying machine for mixing liquids, and liquid with solids. Capacity of each tank 40 gallons. Drive by electric motor through texropes.

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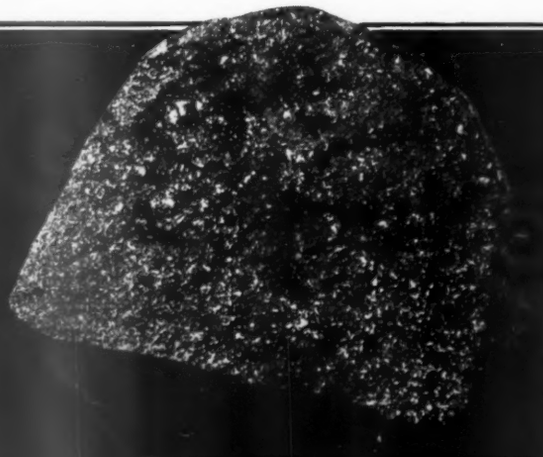

Manufacturers of FOUNDRY, BASIC and HEMATITE qualities. Delivery from stock. Booklet giving analyses, etc., will be sent on request.

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PIG IRON

XUM

RAW MATERIALS—PRICE LIST

(Wednesday, March 6, 1935)

COPPER

	£	s.	d.
Standard cash	28	0	0
Three months	28	6	3
Electrolytic	31	5	0
Tough	29	15	0
Best selected	30	5	0
Sheets	58	0	0
India	41	10	0
Wire bars	31	10	0
Ingot bars	31	10	0
H.C. wire rods	34	5	0
Off. av. cash, February	27	4	1½
Do., 3 mths., February	27	9	7½
Do., Sttlmnt., February	27	4	0
Do., Electro, February	30	8	6
Do., B.S., February	30	0	0
Do., wire bars, February	30	12	1½
Solid drawn tubes			9½d.
Brazed tubes			9½d.
Wire			6d.

BRASS

Solid drawn tubes	8¾d.
Brazed tubes	10¼d.
Rods, drawn	8d.
Rods, extd. or rlld.	4¼d.
Sheets to 10 w.g.	7½d.
Wire	7d.
Rolled metal	6⅝d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN

	£	s.	d.
Standard cash	215	5	0
Three months	212	0	0
English	215	12	6
Bars	217	12	6
Straits	218	0	0
Australian (nom.)		—	
Eastern	218	7	6
Banca	219	10	0
Off. av. cash, February	227	11	6
Do., 3 mths., February	223	15	7½
Do., Sttlmt., February	227	11	9

SPELTER

	£	s.	d.
Ordinary	11	10	0
Remelted	12	15	0
Hard	10	5	0
Electro 99.9	14	2	6
English	12	12	6
India	12	5	0
Zinc dust	17	0	0
Zinc ashes	3	0	0
Off. aver., February	11	18	2¼
Aver. spot, February	11	16	4½

LEAD

	£	s.	d.
Soft foreign ppt.	10	6	3
Empire (nom.)	11	5	0
English	12	5	0
Off. average, February	10	6	3⅜
Average spot, February	10	4	3¾

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	21	10	0
Do., V.M. ex-whse.	22	5	0
Rods	26	0	0

ANTIMONY

	£	s.	d.
English	82	0	0 to 83 0 0
Chinese, ex-whse.	71	0	0
Crude	—		

QUICKSILVER

	£	s.	d.	£	s.	d.
Quicksilver	11	5	0 to	11	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£13 0 0
75%	£18 7 6
Ferro-vanadium—	
35/50	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£14 10 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	£29 15 0
4/6% car.	£23 0 0
6/8% car.	£21 12 6
8/10% car.	£21 12 6
Ferro-chrome—	
Max. 2% car.	£34 0 0
Max. 1% car.	£38 15 0
Max. 0.70% car.	£42 0 0
70% carbon-free	10d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99% (nom.)	5/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export (nom.)	£9 15 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	2	15	0 to	2	16	0
Bundled shrngs.				2	7	6
Mixed iron and steel	2	10	0 to	2	12	0
Heavy cast iron	2	10	0 to	2	12	0
Good machinery	2	12	6 to	2	15	0
Cleveland—						
Heavy steel	2	11	6 to	2	12	6
Steel turnings				1	15	0
Cast-iron borings				1	5	0
Heavy cast iron				2	13	0
Heavy machinery				2	15	0
Midlands—						
Light cast-iron scrap				2	7	6
Heavy wrought iron				3	0	0
Steel turnings, f.o.r.				1	14	0
Scotland—						
Heavy steel				2	10	0
Ordinary cast iron				2	11	3
Engineers' turnings				2	0	0
Cast-iron borings	1	17	6 to	1	18	6
Wrought-iron piling				2	12	6
Heavy machinery				2	16	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	24	0	0
Brass	16	0	0
Lead (less usual draft)	9	10	0
Tea lead	6	10	0
Zinc	8	0	0
New aluminium cuttings	66	0	0
Braziery copper	20	0	0
Gunmetal	23	0	0
Hollow pewter	155	0	0
Shaped black pewter	115	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	69/-
Hematite M/Nos.	68/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
E.C. hematite	81/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/-
Clyde, No. 3	82/-
Monkland, No. 3	82/-
Summerlee, No. 3	82/-
Eglinton, No. 3	82/-
Gartsherrie, No. 3	82/-
Shotts, No. 3	82/-

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	9	12	6 to	9	15	0
Nut and bolt iron	7	10	0 to	8	0	0
Hoops	10	10	0 and up.			
Marked bars (Staffs) f.o.t.				12	0	0
Gas strip	10	10	0 and up.			
Bolts and nuts, ¾ in. × 4 in.				14	2	6 and up.
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.	9	5	0 to	9	7	6
Chequer plts.				10	7	6
Angles				8	7	6
Tees				9	7	6
Joists				8	15	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ⅜ in. (Untested)				8	12	0
Flats—8 in. wide and over				8	12	6
,, under 8 in. and over 5 in.				8	17	6
Rails, heavy	8	5	0 to	8	10	0
Fishplates	12	5	0 to	12	10	0
Hoops (Staffs)				9	7	0
Black sheets, 24g. (4-t. lots)				10	10	0
Galv. cor. shts. (,,)				13	0	0
Galv. flat shts. (,,)				13	10	0
Galv. fencing wire, 8g. plain				14	10	0
Billets, soft	5	10	0 and up.			
Billets, hard	6	17	6 to	7	2	6
Sheet bars	5	0	0 to	5	7	6
Tin bars	5	2	6 to	5	7	6

PHOSPHOR BRONZE

	Per lb. basis.
Strip	9d.
Sheet to 10 w.g.	10d.
Wire	11½d.
Rods	10½d.
Tubes	13d.
Castings	10⅝d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7¼
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8¼
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Bessemer	20.76
Malleable, Valley	18.50
Grey forge, Valley	18.00
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 20/-
Durham foundry	19/- to 22/-
,, furnace	16/6 to 17/9
Midlands, foundry	—
,, furnace	—

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/2 to 19/2
,,	28×20 ,,	36/4 to 38/4
,,	20×10 ,,	26/- to 26/3
,,	18⅞×14 ,,	18/6 to 18/9
C.W.	20×14 ,,	15/6 to 16/6
,,	28×20 ,,	33/- to 33/6
,,	20×10 ,,	23/- to 24/-
,,	18⅞×14 ,,	16/- to 17/-

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£30 0 0 to £31 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.		
Feb. 28 ..	27	7	6	inc.	1/3
Mar. 1 ..	27	17	6	,,	10/-
,, 4 ..	28	7	6	,,	10/-
,, 5 ..	28	1	3	dec.	6/3
,, 6 ..	28	0	0	dec.	1/3

Electrolytic Copper

	£	s.	d.		
Feb. 28 ..	30	10	0	dec.	2/6
Mar. 1 ..	31	0	0	inc.	10/-
,, 4 ..	31	10	0	,,	10/-
,, 5 ..	31	5	0	dec.	5/-
,, 6 ..	31	5	0	No	change

Standard Tin (cash)

	£	s.	d.		
Feb. 28 ..	215	0	0	dec.	15/-
Mar. 1 ..	220	0	0	inc.	100/-
,, 4 ..	219	10	0	dec.	10/-
,, 5 ..	218	10	0	,,	20/-
,, 6 ..	215	5	0	,,	65/-

Tin (English ingots)

	£	s.	d.		
Feb. 28 ..	215	12	6	dec.	5/-
Mar. 1 ..	220	2	6	inc.	90/-
,, 4 ..	219	12	6	dec.	10/-
,, 5 ..	218	12	6	,,	20/-
,, 6 ..	215	12	6	,,	60/-

Spelter (ordinary)

	£	s.	d.		
Feb. 28 ..	11	8	9	dec.	5/-
Mar. 1 ..	11	7	6	,,	1/3
,, 4 ..	11	11	3	inc.	3/9
,, 5 ..	11	10	0	dec.	1/3
,, 6 ..	11	10	0	No	change

Spelter (Electro, 99.9 per cent.)

	£	s.	d.		
Feb. 28 ..	14	0	0	dec.	5/-
Mar. 1 ..	14	0	0	No	change
,, 4 ..	14	3	9	inc.	3/9
,, 5 ..	14	2	6	dec.	1/3
,, 6 ..	14	2	6	No	change

Zinc Sheets (English)

	£	s.	d.		
Feb. 28 ..	21	10	0	No	change
Mar. 1 ..	21	10	0	,,	,,
,, 4 ..	21	10	0	,,	,,
,, 5 ..	21	10	0	,,	,,
,, 6 ..	21	10	0	,,	,,

Lead (English)

	£	s.	d.		
Feb. 28 ..	12	5	0	No	change
Mar. 1 ..	12	5	0	,,	,,
,, 4 ..	12	5	0	,,	,,
,, 5 ..	12	5	0	,,	,,
,, 6 ..	12	5	0	,,	,,

AVERAGE MONTHLY PRICES OF MARKED BARS (SOUTH STAFFS).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1901	9 10 0	9 10 0	9 10 0	9 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 16 8
1902	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 7 6
1903	8 5 0	8 5 0	8 5 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 8 9
1904	8 10 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 10
1905	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 10 0	8 10 0	8 1 8
1906	8 10 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	8 10 0	8 10 0	8 10 0	8 10 0	9 0 0	8 15 10
1907	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0
1908	9 0 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 5 10
1909	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0
1910	8 0 0	8 0 0	8 0 0	8 0 9	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 6
1911	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0
1912	8 10 0	8 10 0	8 10 0	8 15 0	9 0 0	9 0 0	9 0 0	9 8 0	9 10 0	9 10 0	9 10 0	9 15 0	9 1 6
1913	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	10 0 0	9 10 0	9 10 0	9 4 0	9 0 0	9 0 0	9 13 8
1914	8 12 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	8 14 4
1915	9 0 0	9 0 0	9 3 0	10 2 0	10 15 0	11 10 0	12 0 0	12 0 0	12 0 0	12 7 6	12 10 0	13 10 0	11 5 0
1916	13 10 0	13 10 0	14 13 0	15 0 0	15 0 0	15 0 0	15 0 0	15 10 0	15 10 0	15 0 0	15 10 0	15 0 0	14 18 7
1917	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0
1918	15 12 6	16 0 0	16 0 0	16 0 0	16 0 0	16 0 0	16 0 0	16 0 0	16 0 0	17 0 0	17 0 0	17 0 0	16 6 3
1919	18 0 0	18 10 0	20 0 0	20 0 0	23 0 0	23 0 0	23 0 0	24 12 0	25 0 0	25 0 0	25 0 0	25 5 0	22 10 7
1920	26 17 6	27 0 0	28 0 0	30 5 0	30 10 0	33 10 0	33 10 0	33 10 0	33 10 0	33 10 0	33 10 0	33 10 0	31 10 2
1921	31 10 0	30 3 4	27 10 0	27 10 0	27 10 0	24 15 0	21 0 0	20 0 0	20 0 0	17 10 0	17 0 0	16 0 0	23 7 4
1922	16 0 0	14 17 6	14 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 18 1½
1923	13 10 0	13 10 0	13 16 0	14 7 6	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 5 3½
1924	14 10 0	14 10 0	14 10 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	14 17 6	14 17 3½
1925	15 0 0	15 0 0	15 0 6	15 0 0	15 0 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 0 0	14 13 4
1926	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	*	14 10 0	14 0 10
1927	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 0 0	13 0 0	12 18 0	13 15 8
1928	12 10 0	12 10 0	12 2 6	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 2 8½
1929	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 7 6	12 10 0	12 10 0	12 2 3½
1930	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 0 0	12 10 0	12 10 0	12 10 0	12 15 0
1931	12 10 0	12 10 0	12 10 0	12 8 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 3 2
1932	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0
1933	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0
1934	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0	12 0 0
1935	12 0 0	12 0 0											

* No quotation available.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK LIMPET

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.

ZETLAND ROAD, MIDDLESBROUGH.

Notice

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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

ADVERTISER seeks responsible position in foundry making rain-water and sanitary castings. Has had experience as foundry foreman and foreman patternmaker.—Box 174, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

PATTERNMAKER (36), experienced, first-class cylinder hand, steam and oil engines, aero and motor work, capable of setting out work, good knowledge of modern foundry practice, desires improvement in position.—Box 184, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED, Estimator for Steel Foundry. Must be capable of estimating manufacture of cores and moulding produced on the floor and on machines, also must be capable of estimating fettling costs. Give full details of experience and salary required.—Reply to Box 170, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED, Foundry Foreman, experienced in the manufacture of heat-resisting and stainless castings. Practical training in moulding and foundry operations in alloy-steel castings essential.—State age and experience and salary required to Box 182, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

LIGHT-CASTINGS Trade.—Position required as Foreman or Assistant. Experience with first-class light-castings firms, also malleable experience. Technical training. (256)

FOREMAN or Assistant Foreman. Position required by young moulder with supervisory experience in iron and steel works plant and general engineering castings. Understands cupola practice and is technically trained. Position with prospects and opportunities of experience desired. (257)

STEEL-FOUNDRY Foreman requires position. Experience in alloy-steel castings. Heavy shipping, valve, locomotive and general engineering. Estimate all foundry operations. (258)

PATENT

THE Proprietor of the Patent No. 405,946, for "Wire Rope and Method of Making Same," is desirous of entering into arrangements by way of licence and otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country. — All communications should be addressed in the first instance to HASELTINE, LAKE & COMPANY, 28, Southampton Buildings, Chancery Lane, London, W.C.2.

BUSINESS FOR SALE

IRONFOUNDRY, situated Central London, with house attached, established, and in one family about 150 years. The Goodwill of the Business, Foundry Plant, Freehold House and Foundry for Sale.—Box 190, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MACHINERY

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

PNEUMATIC MOULDING MACHINES

406 Osborn Jolt Rollover.
78-in. x 48-in. Britannia Jolt Rollover.
58-in. x 52-in. Macdonald Jolt Rollover.
36-in. x 24-in. Macdonald Jolt Rollover.
24-in. x 16-in. Macdonald Jolt Rollover.
36-in. x 18-in. Tabor Jolt Rollover (Portable).
48-in. x 24-in. Tabor Jolt Rollover (Portable).
18-44 Type Nicholls Jolt Squeezer.
Several Small Jolt Pinlift Machines.
Several Plain Jolt Machines (all sizes).
Several Small Power Squeezers (Split Pattern).

ALL above are in stock.
are *tested* and guaranteed.
would be sent on approval.
are offered on deferred payment system if desired.
can be seen at work.

I am willing to accept other plant *in exchange*.

ALEX. HAMMOND,
14, Australia Road, SLOUGH

FOR Sale, 30-cwt. 2-phase Electrode Electric Steel-melting Furnace complete with Transformers of total capacity of 800 k.v.a. designed to transform primary current at 6,500 volts, 50 periods down to 2-phase current at 90 v. and 70 v. on open circuit. Only been used nine months. Would suit ironfoundry making alloyed or high-duty cast iron. Cost about £6,000; would sell for £600 f.o.b. Belfast.—Details from W. G. WYLLIE & COMPANY, LIMITED, 68, Gordon Street, Glasgow, C.1.

SANDBLAST PLANTS

Room Plants, sizes 12 ft. x 12 ft., 12 ft. x 9 ft. and 6 ft. x 6 ft., made up in cast-iron sections.

Barrel Plants, 30 in. dia. x 36 in. long and 30 in. dia. x 18 in. long rotary barrels.

Cabinet Plants, in sizes 4 ft. x 4 ft. x 4 ft., 36-in. dia. and 30-in. dia. operators' cabinets.

Most of the above by Tilghman and complete with Air Compressors.

HAND MOULDING MACHINES

By Adaptable, Pridmore, Darling & Sellars, etc.; Squeezers by Utard (unused), Samuelson and Britannia, also Farwell Universal Type.

Ladles, Grinding Machines, Exhaust Fans, Blowers, Air Compressors and 500 Electric Motors and Dynamos.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.
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